FIELD GUIDE

FOR THE ACCEPTANCE OF HOT MIX AND BRIDGE DECK WATERPROOFING

Ontario

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To all users of the: **FIELD GUIDE FOR THE ACCEPTANCE OF HOT MIX AND BRIDGE DECK WATERPROOFING, JULY 2007**

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Preface

This Field Guide has been prepared by the Bituminous Section of the Materials Engineering and Research Office to provide procedural guidelines to administer contract requirements on Ministry of Transportation projects in Ontario. The purpose of the Guide is to uniformly implement, across the Province, the acceptance procedures for Hot Mix and Bridge Deck Waterproofing.

The Field Guide is not a specification and does not form part of the contract between the Ministry and the Contractor. Neither the Ministry nor the Contractor are bound by the contents of this Guide unless agreed to in writing, in whole or in part, by both parties.

The Field Guide is primarily intended for use by Ministry of Transportation Regional Staff as well as Consultants administering Ministry contracts involving hot mix placement and bridge deck waterproofing. The guide outlines the required sampling, testing and recommended acceptance procedures, in accordance with the applicable Ontario Provincial Standard Specifications (OPSS) and current Ministry Special Provisions.

Any wording changes since last year's Field Guide have been shown in bold.

Some Major Specification Changes and Highlights Since the 2006 Field Guide

This Section highlights some of the major specification changes that have **been made** since the **2006** Field Guide was published.

The major change this year is that OPSS 313 has been re-written and OPSS 1149 has been deleted and replaced by OPSS 1151. These two new specifications, designated as OPSS.PROV, are specifically written for Provincial use and generally involve the consolidation of the existing requirements that were formally covered in numerous specifications as well as the complete removal of statements that pertained to the old Marshall mixes. The specifications which have been impacted by these changes and referred to in past Field Guides are listed below:

SP 103F31 - modified
SP 103S34 - deleted – i.e. covered in the new documents
SP 103S35 - modified
SP 103S38 – deleted – i.e. covered in the new documents
SP 103F40 – deleted – i.e. covered in the new documents
SP 313F44 - deleted and replaced by OPSS.PROV 308

The adminstrative changes which involve the re-numbering of specifications, sections, subsections and clauses are only\ shown in the applicable chapters in this Field Guide. Only the substantial changes in content that have been introduced this year are being summarized here as follows:

Chapter 1 – Sampling and New Initiatives

In order to address numerous concerns with overweight samples that have been received by the QA laboratories as well as other issues of concern, the following sampling-related changes have been implemented this year:

1) **Size ranges have been imposed for all mix types, to replace the simple minimums that were in place;**
2) **No single receptacle can weigh more than 30 kg;**
3) **The spacing of cores has now been increased to 1.0 ± 0.1 metres (i.e. from 0.5 ± 0.1 metres);**
4) **PGAC sampling has been reduced to one sample for each 10,000 tonne lot of HMA; and**
5) **Submission of PGAC samples prior to paving are not required, unless a modified SP 111S09 is included and the PGAC contains Polyphosphoric Acid (i.e. PPA).**

Chapter 2 – Combined End-Result Acceptance For Hot Mix

The following changes have been made to the End-Result Requirements for Hot Mix Acceptance:

1) **Independent mix checks are now required to be submitted to the Contract Administrator using a new "Certificate of Independent Check of Mix Design" Form PH-CC-8221IMC;**

2) On a lot-by-lot basis, MTO now permits QA test results to be used for payment purposes, at the Contractor's request. However, in this case, no Referee testing would be allowed for that lot;

3) The Contractor can now carry out repairs for a lot, in lieu of accepting a payment factor, only if the payment factor for that lot is less than 0.94; and

4) Whenever repairs are being carried out, a minimum length of 250 metres is now required and single repair areas must be separated by at least 100 metres.

5) It should also be noted that, for this year (although this is not specifically referred to in this Field Guide), the specifications make it clear when and how much ground new Roof Shingle Tabs (RST) are allowed in mixes which allow some Recycled Asphalt Pavement (RAP). However, the quantities of RST that are permitted are limited (see OPSS 1151 for details).

Chapter 5 - Segregation

There are no major changes to the requirements surrounding segregation this year other than the fact that SP 103S38 has now been eliminated and many of the statements that were formally in the SP 103S38 have now been included in OPSS 313.

Chapter 6 - Smoothness

Since many of the subsections and clauses have now been renumbered in OPSS 313, these changes are now reflected in SP 103F31. The following changes have also been made this year:

1) OPSS 313 now includes a significantly reduced list of areas that are specifically exempt from surface smoothness measurements. However, any areas that were included in previous exemption lists can be considered as fill-ins, if it is deemed appropriate to do so by the applicable Region.
2) The Tender Opening Date Reduction Factor (TODRF) has been increased to 1.0 for 2007 where:
    a. The surface course consists of SMA;
    b. The construction consists of a single lift of hot mix (with or without levelling and/or padding) placed on the pulverized grade is not included in the contract; or
    c. In areas on resurfacing contracts, the Contractor is required to match elevations to a curb or barrier wall which was not constructed on the Contract, is within 1.5 m of the lane being paved and the paver has simultaneously paved both the lane and shoulder, if there is a shoulder; and
3) The TODRF has been increased to 0.8 for 2007 for a single lift placed on Expanded Asphalt Mix (EAM).

Chapter 7 – Bridge Deck Waterproofing

The only change this year is that samples of waterproofing material must be placed in either 4 L "Paint Cans" or standard metal concrete cylinder moulds (i.e. they can't be made of plastic or some other material).

Chapter One

HOT MIX SAMPLING FOR ASPHALT CEMENT CONTENT AND GRADATION, AIR VOIDS/VMA, COMPACTION, PGAC AND OTHER INITIATIVES AND CHANGES IN HOT MIX

1-1 General

Contracts, **awarded prior to March, 2007,** with mix tender quantities of less than 10,000 tonnes, **usually** include Special Provision No. 103F35, entitled "End Result Specification for Acceptance of Hot Mix (Aggregate Gradation, Asphalt Cement Content, Air Voids, VMA, Compaction) Based on Owner Testing" **or** for those conracts with at least 10,000 tonnes, a similiarly-titled Special Profision No. 103F34 ".......Based on Contractor Testing" . **Contracts issued between March 2007 and prior to July 2007, include similar specifications but with the fill-ins removed, designated 103S35 and 103S34.**

However, for contracts issued after July 2007, Special Provision 103S34 has been deleted and the new Provincial specifications OPSS.PROV 313 and OPSS.PROV 1151 include all of the statements that were formally included in that SP. Although Special Provision 103S35 still remains, many of its statements have also been included in these new Provincial specifications.

For the purposes of this and following Chapters, OPSS.PROV 313, OPSS.PROV 1151 and SP 103S35 will henceforth be referred to as "313", "1151" and "S35", respectively.

Methods of sampling hot mix for aggregate gradation, asphalt cement content, air voids and bulk relative density testing are included in Section 1-2, core sampling of hot mix for compaction is included in Section 1-3 and sampling of PGAC is included in Section 1-4.

Superpave mix design has now been fully implemented in Ontario **for the last two years.** Both Superpave and Stone Mastic Asphalt (or SMA) mixes are designed using a gyratory compactor which requires larger (20 - 35 kg) samples for testing the ERS attributes than Marshall mixes.

In order to address numerous concerns with overweight samples that have been received by the QA laboratories as well as other issues of concern, the following sampling-related changes have also been implemented this year:

1) **Size ranges have been imposed for all mix types, to replace the simple minimums that were in place;**
2) **No single receptacle can weigh more than 30 kg;**
3) **The spacing of cores has now been increased to 1.0 ± 0.1 metres (i.e. from 0.5 ± 0.1 metres)**
4) **PGAC sampling has been reduced to one sample for each 10,000 tonne lot of HMA; and;**
5) **Submission of PGAC samples prior to paving are not required, unless a modified SP 111S09 is included and the PGAC contains PPA.**

As far as new initiatives go, it should be noted that, this year, the tack coating Special Provision, SP 313F44 has now been deleted and replaced by OPSS.PROV 308 and SP 308F01. A description of this specification is included in Section 1-5 of this chapter.

1-2 Sampling For Aggregate Gradation, Asphalt Cement Content and Air Voids/VMA

1-2.1 Sample Size

For all Superpave and SMA mixes, a set of three samples each with **masses** of 20 to **45** kg [see **TABLE 2**, entitled "Sample Size and Frequency" in **313** - i.e. 2 or more plates per sample will be required, if plate sampling is being carried out], shall be taken by the Contractor for each sublot [see Notes 1) and 2)]. One sample will be retained by the Contractor for Quality Control (QC) testing and the other two from each set of three will be delivered to the Owner. The Owner may perform Quality Assurance (QA) testing on one sample and the other sample will be stored for possible re-testing for outliers or for referee testing. For SMA, three additional 3 **to 5** kg samples will also be required (possibly another plate, if plate samples are being taken) from one of the sublots in each lot which will be split for QA , QC and referee "draindown" testing (see **TABLE 2 in 313** and Section 1-5.5).

Notes: 1) Although plate sampling of SMA and Superpave mixes is one of the methods that can be used, the larger samples required for gyratory testing means that at least twice as many plates will be needed as was formerly required for Marshall mixes. As a result of this, an alternative sampling method **is permitted**. In addition, it is permitted to place samples of SMA and Superpave mixes in a maximum of two receptacles and also that it won't be mandatory to mix them once they are received at the testing laboratory.

2): The larger sample size will be applicable when samples are designated for testing to the maximum number of gyrations. The frequency of the larger samples shall be two per lot, as designated by the Contract Adminstrator.

1-2.2 Sampling Frequency

The sampling frequency is dependent on the lot size with the sublot size being set at the Contract Administrator's discretion in consultation with the Contractor within the parameters given in the Special Provision.

When a lot is defined as 5000 t of any one type of hot mix produced, then the lot will normally be divided into 10 approximately equal sublots of 500 t each and a set of three samples**, each with masses** of 20 to **45** kg **(see TABLE 2 in 313)** will be required from each sublot [see Notes 1) and 2]. For SMA, 3 additional 3 **- 5** kg samples (probably another plate, if plate samples are being taken) will also be required from one of the sublots in each lot for draindown testing. Note that an exception to these requirements may be made, if lightweight aggregates are used.

1-2.3 Sampling Methods and Random Sample Locations

Random samples are to be obtained by the methods permitted in the Contract. Refer to the Contract to determine which method is permitted for each hot mix type. The methods which may be permitted are (1) plate samples (2) coring and any acceptable alternative sampling method (to replace plates) proposed by the Contractor as long as each sample is taken after its designated truckload has been unloaded at the site.

The sampling locations and lot/sublot sizes should be determined on a daily basis. They cannot be determined at the start of a contract on a tonnage basis because there may be a need to terminate a lot prior to reaching a pre-determined tonnage.

1-2.3.1 Quantity Method for Plate Samples

1. When production is expected to proceed with 5000 t lots with 10 sublots, divide each lot as follows:

   Example: Superpave 12.5 to have a set of three 10 kg samples obtained from each 500 t sublot within a 5000 t lot, i.e. Lot 3.

Lot 3	Sublot	1	0	-	≤ 500 t
		2	>500	-	≤ 1000 t
		3	>1000	-	≤1500 t
		4	>1500	-	≤ 2000 t
		5	>2000	-	≤ 2500 t
		6	>2500	-	≤ 3000 t
		7	>3000	-	≤ 3500 t
		8	>3500	-	≤ 4000 t
		9	>4000	-	≤ 4500 t
		10	>4500	-	≤ 5000 t

2. For each sublot, select a random number either from a random number table or generated by a calculator or computer. A table of random numbers is given in Appendix A.

Lot 3	Sublot 1	0.750
	Sublot 2	0.446
	etc.	etc.

3. Using the random number determined for each sublot, identify the "tonne to be sampled". In reality, this number is only used to identify the truck load from which the sample is taken.

   Example: random number x lot or sublot size = tonne to be sampled
   0.750 x 500 = 375

4. Set up a table with each tonne to be sampled as follows:

Superpave 12.5: Sampling Locations (Set of Three 10 kg samples) - 5000 t Lots

Superpave12.5 Lot/Sublot No.	Sublot Size	Random No. for Tonne	"Tonne to be Sampled" =(Random No. X 500) + start tonne for sublot
3/1	0 - ≤500 t	.750	375
3/2	>500 - ≤1000 t	.446	723
3/3	>1000 - ≤1500 t	etc.	etc.
3/4	>1500 - ≤2000 t	etc.	etc.
3/5	>2000 - ≤2500 t	etc.	etc.
3/6	>2500 - ≤3000 t	etc.	etc.
3/7	>3000 - ≤3500 t	etc.	etc.
3/8	>3500 - ≤4000 t	etc.	etc.
3/9	>4000 - ≤4500 t	etc.	etc.
3/10	>4500 - ≤5000 t	etc.	etc.

Note: 3) DO NOT PROVIDE THE SAMPLE TONNE INFORMATION TO THE CONTRACTOR PRIOR TO THE TRUCK BEING LOADED.

5. A copy of the sample table is provided to the employee, designated by the Contract Administrator, who will be responsible for identifying the truck load containing the sample tonne. A running total of hot mix production will have to be maintained for each item. A printing calculator or adding machine will minimize any chance of error. When the truck containing the "Tonne to be sampled" is identified, the person must:

   a. Mark the top of the weigh ticket "Load to be sampled".

   b. Write on the back of the ticket the mass of the sample, the lot number and sublot number (where applicable).

      Example: Mass 20 kg
      Lot 3
      Sublot 1 etc.

   c. Draw a diagonal line across the face of the ticket with a bright coloured marking pen. This will help draw attention to the fact that the load is to be sampled.

6. The road inspector must ensure that the Contractor's representative is fully aware of the load to be sampled.

7. The Contractor's representative is then required to take the set of three plate samples [for SMA and Superpave mixes, 2 or more plates per sample will be required, if plate samples are being taken – [i.e. see **TABLE 2 in 313** and Notes 1), 2) and **4)**] anywhere within the load (but recommended within the middle third of the load).

8. All plate samples shall be taken at the same transverse offset.

9. The samples shall only be obtained from a machine laid mat, away from the wheelpaths of the paving equipment and far enough away from any pavement edge to ensure that the whole plate is covered by the mat.

10. After the sample has been taken, the Contractor is then required to properly label each sample with all relevant information (including its station and offset) and package the sample as designated in the contract. For each set of three plate samples, one plate sample should be designated as "QC" and the other two plates "QA" and "Referee" [for SMA and Superpave mixes, each of the samples will require two or more plates per sample [i.e. see **TABLE 2 in 313** and Notes 1), 2) **and 4)**].

11. The packaged (i.e. bag, box etc.) "QA" and "Referee" samples, should be placed in heavy gauge plastic bags with an area on each bag in which a date and a code and all other relevant information (such as Contract number, lot, sublot, station and offset) can be written using a regular permanent magic marker. The bags and seals may be obtained from the appropriate Regional Quality Assurance Section. The Contract Administrator's representative may then seal the bag with a Bag Guard Seal (tie wrap) which has a customized MTO code. If the seal is applied he must then write the same code onto the bag along with the date the bag was sealed.

12. The samples should then be delivered to the designated location, as detailed in the Contract.

13. After the paver has passed over each plate, then examine the pavement surface. If the pavement surface is found to be homogeneous, then the set of samples is acceptable, providing that the samples on each of the three plates [6 or more plates for SMA and Superpave mixes [i.e. see **TABLE 2 in 313** and Notes 1), 2) **and 4)**] have a minimum mass

of 10 kg. However, if the pavement sample is disturbed, in some way, or if any one of the plate samples has less than 10 kg, then the Contractor must discard the set of plate samples and obtain a new set of three [i.e. 6 or more plates in total for SMA and Superpave mixes – see **TABLE 2** in **313** and Notes 1), 2) **and 4)**] as soon as possible. In all cases, ensure that the full thickness of the pavement has been obtained on the plate.

Note: 4) The size of the plate, if plate sampling is used, may be changed according to mat thickness, in order to yield a minimum of 10 kg. For example, for a lift 40 mm thick, a plate with minimum dimensions of 0.35 x 0.35 m (14 x 14 in.) is required to obtain 10 kg of mix. For different mat thicknesses, refer to Table 1-1 given below:

TABLE 1-1: APPROXIMATE MASS OF Superpave 12.5 ON PLATE (kg)

MAT THICKNESS (mm)	PLATE SIZE					
	.15 x .20	.25 x .25	.30 x .30	.35 x .35	.45 x .45	m
	6 x 8	10 x 10	12 x 12	14 x 14	18 x 18	in
100	6.7	14.0	20.2	27.5	45.5	
80	5.4	11.2	16.2	22.0	36.4	
70	4.7	9.8	14.1	19.3	31.8	
60	4.0	8.4	12.1	16.5	27.3	
50	3.3	7.0	10.1	13.7	22.7	
40	2.7	5.6	8.1	11.0	18.2	
30	2.0	4.2	6.0	8.2	13.6	
25	1.7	3.5	5.1	6.9	11.4	

1-2.3.2 Quantity Method for Coring Samples

1. Determine the sampling locations using steps 1 to 6 in the procedure for "Quantity Method for Plate Samples" for the 5 kg sampling locations.
2. The Contractor is required to obtain the cores, label, package and deliver them to the designated location, as detailed in the Contract.

1-2.3.3 Quantity Method for Screed Auger Chamber Samples

1. When production is expected to proceed with 5000 t lots with 10 sublots, divide each lot as follows:

Example: Superpave 12.5 to have a set of three **20** kg samples obtained from each 500 t sublot within a 5000 t lot.

Superpave 12.5 Lot/Sublot No.			
2/1	0	-	≤ 500 t
2/2	> 500	-	≤1000 t
2/3	>1000	-	≤1500 t
2/4	>1500	-	≤2000 t
2/5	>2000	-	≤2500 t
2/6	>2500	-	≤3000 t
2/7	>3000	-	≤3500 t
2/8	>3500	-	≤4000 t
2/9	>4000	-	≤4500 t
2/10	>4500	-	≤5000 t

2. For each sublot, select a random number from the random number table.

Example :	Lot 2	Sublot 1	0.750	
	Lot 2	Sublot 2	0.446	etc.

3. Using the random number, identify the "tonne to be sampled". In reality, this number is only used to identify the truck load from which the sample is taken.

   Example: random number x lot size = tonne to be sampled
   0.750 x 500 = 375

4. Set up a sampling table with each tonne to be sampled, as illustrated below:

   Superpave 12.5 : Set of three **20** kg samples from each Sampling Location - 5000 t lot

Superpave 12.5 Lot/Sublot No.	Sublot Size	Random No. for Tonne	"Tonne to be Sampled" =(Random No. x 500) + start tonne for sublot
2/1	0 - ≤ 500 t	.750	375
2/2	> 500 - ≤1000 t	.446	723
2/3	>1000 - ≤1500 t	etc.	etc.
2/4	>1500 - ≤2000 t	etc.	etc.
2/5	>2000 - ≤2500 t	etc.	etc.
2/6	>2500 - ≤3000 t	etc.	etc.
2/7	>3000 - ≤3500 t	etc.	etc.
2/8	>3500 - ≤4000 t	etc.	etc.
2/9	>4000 - ≤4500 t	etc.	etc.
2/10	>4500 - ≤5000 t	etc.	etc.

Note: 5) DO NOT PROVIDE THE SAMPLE TONNE INFORMATION TO THE CONTRACTOR PRIOR TO THE TRUCK BEING LOADED.

5. A copy of the sample table is provided to the employee, designated by the Contract Administrator, who will be responsible for identifying the truck load containing the sample tonne. This will require the designated individual to maintain a running total of hot mix production for each mix. A printing calculator or adding machine will minimize any chance of error. When the truck containing the "Tonne to be sampled" is identified, the person must:

   a. Mark the top of the weigh ticket "Load to be sampled".

   b. Write on the back of the ticket the mass of the sample, the lot and/or sublot number and the random number for the side of the screed for sampling.

Example:	Mass	10 kg
	Lot	3
	Sublot	1

   c. Draw a diagonal line across the face of the ticket with a bright coloured marking pen. This will help draw attention to the fact that this load is to be sampled.

6. When the load is received at the paver, the road inspector will inform the Contractor's representative that the sample is to be taken anywhere within the load.

7. The Contractor is required to obtain the sample, label each sample with all relevant information (including its station and offset), then package and deliver the samples to the designated location, as detailed in the Contract. For each set of three auger samples, one sample should be designated as "QC" and the other two "QA" and "Referee".

8. The packaged (i.e. bag, box etc.) "QA" and "Referee" samples, should be placed in heavy gauge plastic bags with an area on each bag in which a date and a code and all other relevent information (such as Contract number, lot, sublot, station and offset) can be written using a regular permanent magic marker. The Contract Administrator's representative may then seal the bag with a Bag Guard Seal (tie wrap) which has a customized MTO code. If the seal is applied he must then write the same code onto the bag along with the date the bag was sealed.

1-3 Core Sampling For Compaction Testing

Core samples for compaction testing are based on the same lots and sublots defined for AC/gradation and air voids testing. For each 500 t sublot, a randomly-selected location will be chosen for a set of three cores taken by the Contractor.

1. The locations for the set of three cores are determined by selecting pairs of random numbers from random number tables. The first number will be used to calculate the distance into the sublot and the second for the offset of the core in accordance with the following example:

   Example: Superpave 19 to have a set of three cores obtained from each 500 t sublot within a 5000 t lot (Lot 3).

   The Superpave 19 was placed between Sta. 22+245 and Sta. 30+195 over a 3.75 metres width (i.e. one lane).

   Length of Lot 3: 22+245 - 35+495 = 13,250 metres
   Length of sublots: 13250 ÷ 10 = 1,325 metres

Lot 3	Sublot	1	22 + 245	-	23 + 570
		2	23 + 570	-	24 + 895
		3	24 + 895	-	26 + 220
		4	26 + 220	-	27 + 545
		5	27 + 545	-	28 + 870
		6	28 + 870	-	30 + 195
		7	30 + 195	-	31 + 520
		8	31 + 520	-	32 + 845
		9	32 + 845	-	34 + 170
		10	34 + 170	-	35 + 495

2. From the random number tables, select pairs of numbers for each sublot.

Example:	Lot 3	Sublot	1 -	.235,	.713
			2 -	.732,	.030
			etc.	etc.	etc.

3. Using the first number of each pair, determine the longitudinal location of the cores, and using the second number from each pair, determine the transverse location.

Example: Lot #3: 1st random # X length of sublot = Distance into lot.
Sublot 1 .235 X 1325 = 311.4 m metres or
Sta. 22+245 + 0+311.4 = Sta. 22+556.4

2nd random # x pavement lane width for the lot = offset Rt. E.P.
.713 x 3.75 = 2.69

Lot 3, Set of three cores @ Sta. 22+556.4 offset 2.69 Rt. E.P.

4. Give the Contractor the location of the cores after rolling of the lot is complete [see Note 6)].

5. The Contractor must extract the cores no later than the next regular working day following the completion of the entire lot. However, if it is desired to obtain the cores immediately after the completion of the sublot, then the Contractor must demonstrate to the Contract Administrator that the pavement can be made sufficiently cool (by using dry ice, for example) prior to coring.

6. If the core location falls less than 250 mm from an unconfined pavement edge, then the cores are to be relocated a distance of 250mm from the edge of the lane. Coring on bridge decks will not be allowed, unless permitted by the Contract Administrator and cores cannot be taken within 250 mm of a longitudinal or transverse joint, or the edge of pavement.

7. The set of three cores must be taken from the same lane, at the same transverse offset, and within a spacing of **1.0 ± 0.1** metre from one another.

8. The cores must have a minimum diameter of 150 mm and a maximum nominal diameter of 200 mm and must consist of the full layer being sampled and at least one underlying layer, if one is present. All cores (including those taken for possible re-testing), should be inspected for defects. If a core is damaged, a replacement core must be extracted at a location adjacent to the orginal core.

9. Each core shall be clearly marked with all relevant information including its Contract number, lot and sublot number using a permanent metallic paint marker. Silver (or gold) markers appear to produce the best results and may be obtained at any well-stocked art supply store [see Note **7**)]. For each set of three cores, one of the cores shall be for "QC" testing, one for "QA" testing and one for "Referee" testing, as designated by the Contract Administrator. However, the appropriate designation should be clearly marked only on the QC core which the Contractor will retain. The two remaining cores should be delivered to the Owner without marked designation or both could be marked "QA/Referee". The CA or the QA laboratory will choose one of the two for QA testing and retain the other for Referee testing, if required.

10. The integrity of all cores must be protected during transport and until the testing is carried out. One method that could be used to protect the cores is to first individually wrap each core in cellophane or similar material [see Note 8)], place it in a metal or plastic cylinder (such as the type used for casting concrete cylinders and the void between the core and cylinder wall filled with fine sand to prevent movement or the core within the cylinder. Once again note that only the cylinder containing the QC core should be marked "QC".

11. The two QA/Referee cylinders, should be well-wrapped (in bubble wrap or newspaper for example) and placed in heavy gauge plastic bags with an area on each bag in which a date and a code and all other relevent information (such as Contract number, lot, sublot, station and offset) can be written using a regular permanent magic marker. The bags and seals may be obtained from the appropriate Regional Quality Assurance Section. The Contract Administrator's representative must

then seal the bag with a Bag Guard Seal (tie wrap) which has a customized MTO code. If the seal is applied he must then write the same code onto the bag along with the date the bag was sealed. To provide additional protection to the cores, the heavy-gauge bags containing the cylinders could be placed in small cardboard or metal boxes and surrounded by appropriate packaging material (again more bubble wrap or newspaper could be used for this purpose).

12. Immediately after coring, the Contractor must clean out and sponge dry all core holes, fill them with hot mix and compact the hot mix according to clause **313.07.15.04** of **313**. A mechanical compactor with a round foot slightly smaller than the diameter of the core hole must be used. The holes must be filled and compacted in such a way as to conform with the adjoining undisturbed pavement.

13. The Contract Administrator must ensure that all cores have been obtained at their proper locations [i.e. chosen from pairs of random numbers (as in 2 and 3) given above] and that all of the core holes have been properly filled.

14. Once any referee cores have been received, the Quality Assurance laboratory should inspect them for damage and any undamaged cores should then be carefully re-packaged. However, if any of the cores have been damaged, then the Contract Administrator should be immediately notified.

Notes: 6) When a core location coincides with a localized area which has been identified by the Contractor prior to paving and determined by the Contract Administrator to be unable to provide adequate support for the Contractor's compaction operations (and consequently result in lower compaction), then the core shall be moved to the nearest location outside of the area identified. It should be noted that these locations shall not be identified by the Contractor after the compaction core has been taken or after the compaction test result(s) have been received.

7) Two types of paint markers that the Bituminous Section have found to be suitable include the Sandford, silver coat, bold tip metallic from Basic Office Products and the Pilot Paint Marker, Bullet Tip from Grand and Toy. Both are about $6.00 each. Any well-stocked art suppy store should have similar products.

8) It should be noted that when a core contains more than one lift of hot mix and the bond between the lifts breaks during coring or at any time prior to being wrapped for transport, then each lift within the core shall be clearly marked with all appropriate information. In addition, the separated lifts should be individually wrapped before being placed in the plastic or metal container.

1-4 Sampling PGAC

It should be noted that submission of PGAC samples prior to paving are not required, unless a modified SP 111S09 is included in the contract and the PGAC contains Polyphosphoric Acid (PPA). In any case, to ensure that PGAC being sampled and tested is representative of the material used in production, it is recommended that the Contract Administrator bag and apply security seals to the QA and Referee samples (cans) taken at the hot mix plant.

In accordance with the Contract requirements, the total tender quantities of hot mix items should be divided into lots for PGAC sampling purposes, in accordance with the following:

a) < **10**,000 tonnes:	**One** lot
b) ≥ 10,000 tonnes:	Each 10,000 tonnes will be treated as one lot. **If** the last lot **has** less than **5**,000 tonnes, **then it will be added to the previous lot. However, if is greater than or equal to 5000 tonnes but less than 10.000 tonnes, then it will be treated as a separate lot.**

In the presence of the Contract Administrator or his representative, the Contractor is required to take three 1-litre samples (cans) of PGAC which are randomly chosen within each **lot**. An example of random sampling for PGAC is given below:

1. When **27,750 t of HMA** production is expected, **PGAC sampling shall proceed** as follows:

   Example: Superpave 12.5 FC1 to have a set of three 1-litre samples (cans) obtained from each 10,000 t lot, i.e. **Lots 1 to 3**.

Lot 1	0	**to**	**≤ 10,000 t**
Lot 2	**> 10,000**	**to**	**≤ 20,000 t**
Lot 3	**> 20,000**	**to**	**≤ 27,750 t**

2. For each lot, the Contract Administrator must select a random number either from a random number table or generated by a calculator or computer. A table of random numbers is given in Appendix A.

Lot 1	0.872
Lot 2	0.125
Lot 3	**0.465**

3. Using the random number determined for each lot, the Contract Administrator will identify the "tonne to be sampled".

   Example: random number x lot size = tonne to be sampled

   0.872 x **10,000** = **8720**

   0.125 x **10,000** = **1250**

   0.465 x 7,750 = 3604

4. The Contract Administrator will then set up a table with each tonne to be sampled as follows:

Superpave 12.5 FC1: Sampling Locations (Set of Three 1-litre samples) - 10000 t Lots

Superpave 12.5 FC1

Lot No.	Lot Size	Random No. for Tonne	"Tonne to be Sampled" =(Random No. X **10,000**) + start tonne for lot
1	0 - ≤ **10,000** t	0.872	**8720**
2	>10,000 - ≤ **20,000** t	0.125	**11,250**
3	**> 20,000 - ≤ 27,750** t	**0.465**	**23,604**

5. The Contractor will then take three 1-litre sampling cans of the PGAC which will be used in the "tonne to be sampled". The samples are taken near the point of injection into the mix (usually a spigot on the PGAC supply line), in the presence of the Contract Administrator or his representative.

6. After the samples have been taken, the Contract Administrator must immediately take possession of the QA and referee samples (for testing by the QA laboratory). The Contractor will retain the QC sample (for testing by the QC laboratory). Since the samples will be hot, the Contract Administrator should take the QA and referee sample to a location (such as the Contract Administrator's office) which will allow them to cool sufficiently in order that they can be bagged.

7. Once they are cooled, both the QA and referee samples can be inserted into the same type of heavy gauge plastic bag that the Regional Quality Assurance Section provides for hot mix. Packing material should be placed around the cans to try to keep them upright and so that they

don't knock against one another and become uncovered. Any relevent information (such as Contract number, PG grade, the plant that produced it, where it was sampled etc.) should be written on the bag using a regular permanent magic marker. Other relevent paper work associated with the samples may be placed in the bag. The Contract Administrator's representative should seal the bag with a Bag Guard Seal (tie wrap) which has a customized MTO code (again the same type of ties being used for hot mix). When the seal is applied the Contract Administrator must then write the same code onto the bag along with the date the bag was sealed.

8. Once sealed, the samples can be given back to the Contractor for delivery to the QA laboratory or the Contract Administrator may retain and deliver them to the laboratory himself.

9. The QA laboratory will unseal the samples and note down the security number which must be reported along with the test result (if the sample is tested). The referee sample and any untested QA samples will be stored.

1-5 Other Initiatives and Changes in Hot Mix

A tack coat specification was introduced a few years ago. **The tack coat specification will be included on some contracts in 2007 and is described in the following subsection.**

1-5.1 Tack Coat Specification

Selected Ministry contracts may contain **OPSS.PROV 308 and SP308F01**.

This section provides guidance on items which require action on the part of the Contract Administrator. As with all specifications covered in this Field Guide, the Contract Administrator must always refer to the Contract documents for administering the specifications.

Products

The specified product for tack coating consists of SS-1 emulsion which is diluted 50:50 with water (usually by the Contractor rather than the supplier).

The use of products other than diluted SS-1 will be permissible. Such requests are likely to be made for late season paving or for paving situations when a "fast break" of the emulsion is desirable (e.g. night paving). The Contractor is required to give the Contract Administrator fourteen (14) calendar days notice of the proposed use of alternate products and the Contract Administrator will be required to respond within 7 calendar days by either agreeing to the proposal or not accepting it with reason(s). When such a request is received, the Contract Administrator must review it with the applicable Quality Assurance section, who in turn will contact Head Office if necessary.

Equipment

Tack coat for main lane paving must be done using pressure distributors capable of applying the product uniformly. Distributors must be equipped with volume determining devices. The use of pressure wands will be acceptable for irregularly shaped areas such as tapers.

Application

This Special Provision specifies which lifts of construction are to be tack coated and may vary from Region to Region. In general terms, all existing and milled surfaces will require tack coating. Depending upon the designer option selected, the final binder course lift may also require tack coating, but some Regions may specify it on the final binder course only if this lift has been left over the winter. You must determine for your contract which option has been selected. The surface to be tacked must be free of contamination and standing water.

There may be extenuating circumstances when the use of tack coat may be waived. For example, if the final binder course is specified to be tack coated but construction is carried out such that the surface course is placed on the new binder course within a day or so and the binder course surface is clean, tack coat may not be necessary. Another situation when the use of tack coat could be reviewed is if paving must proceed late in the year, and the Contract is experiencing severe traffic delays because of the time required for the emulsion to break. It should be noted, however, that any decision to waive the use of tack coat must be made by the Contract Administrator in consultation with the applicable Regional Contract Office (who may involve their Quality Assurance Section or Head Office).

Application Rates

There are three different rates of application specified: 0.50 kg/m^2 for protection board, 0.35 kg/m^2 for existing, milled surfaces, expanded asphalt surfaces and the surfaces of any binder course travelled over the winter, and 0.20 kg/m^2 for cold in place material and binder course surfaces constructed in the same calendar year (when required). The Contractor's Quality Control (QC) plan usually specifies how the application rate is to be controlled by the Contractor. Reference should be made to the QC plan and conformance to it is required in the same manner as for other quality items. The Contract Administrator must ensure that the distribution is uniform both transversely and longitudinally and that the full lane width being paved is tack coated. Too much tack coat is not desirable as it can bleed through the mix and result in fat spots or, in extreme cases, pavement flushing.

If the specified application rate appears inappropriate (i.e. results in excessive runoff or does not appear to be create an asphalt film which is thick enough), the applicable Regional Quality Assurance Section should be contacted to review the application rate in conjunction with the Bituminous Section.

Feedback

Field staff are encouraged to provide feedback to the Ministry on the use of this specification in their contracts. Such information can be passed on to the applicable Regional Quality Assurance office who can transmit it to Head Office. Items such as application rate and construction impacts (e.g. traffic delays due to time required for emulsion to break, if any) are of particular interest.

Chapter Two

"COMBINED" END-RESULT ACCEPTANCE OF ASPHALT CEMENT/GRADATION, COMPACTION AND AIR VOIDS/VMA

2-1 General

As noted in Section 1-1, new Provincial specifications OPSS.PROV 313 and OPSS.PROV 1151 include all of the statements that were formally included in Special Provision 103F34/103S34 for contracts with hot mix tender item quantities of 10,000 tonnes or more and most of the statements that were included in 103SF35 for contracts with hot mix tender quantities less than 10,000 tonnes.

As in Chapter 1, OPSS.PROV 313, OPSS.PROV 1151 and SP 103S35 will be henceforth be referred to as "313", "1151" and S35, respectivley.

For 2007 Contracts, the main changes have been made to the End-Result Requirements for Hot Mix Acceptance are summarized below:

1) Independent mix checks are now required to be submitted to the Contract Administrator using a new "Certificate of Independent Check of Mix Design" Form PH-CC-8221IMC;
2) Independent mix checks now require that BRD's must also be carried out for the blended coarse aggregate and the blended fine aggregate;
3) On a lot-by-lot basis, MTO now permits QA test results to be used for payment purposes, at the Contractor's request. This change was implemented to address situations, such as those close to the end of paving a contract, where the Contractor may wish to shut down his operation before the QA testing and QC/ QA comparison has been completed for the entire lot. However, in this case, no Referee testing would be allowed for that lot;
4) The Contractor can now carry out repairs for a lot, in lieu of accepting a payment factor, only if the payment factor for that lot is less than 0.94; and
5) A number of changes were implemented to address MTO's concerns over the very narrow strip repairs that were being done to repair rejectable lots in the past. Now repairs must be:
    a. A minimum length of 250 metres in a single lane;
    b. At least 125 m in each lane if a repair extends into an adjacent lane;
    c. At least 100 m apart or they must be combined into is now required and single repair areas must be separated by at least 100 metres.

More details regarding the above are given in this Chapter.

2-2 Contractor Mix Designation

For Superpave mixes, the mix design submission, **shall be submitted to the Contract Administrator using a new "Certificate of Independent Check of Mix Design" Form PH-CC-8221IMC which includes certification from an independent laboratory stating that:**

a) the Independent laboratory prepared all samples and conducted all testing required by the laboratory procedure according to LS-316 to determine the values of mix and aggregate properties listed in Table 7 of 1151; and
b) the mix meets the requirements and tolerances given in Table 7 of 1151.

However, for contracts containing S35, this is only required for tender item quantities more than 2000 tonnes.

The Ministry is no longer required to verify mix designs as a standard practice. Instead, after receiving all required documents and samples from the Contractor, the Contract Administrator will review the mix design and the Job Mix Formula (JMF) and provide the Contractor with written confirmation advising him of any non-conformances within 4 Business Days.

A sample confirmation letter from the Contract Administrator, entitled "SAMPLE LETTER TO CONTRACTOR #2-1", is included at the end of this Section.

The Contractor shall not place any mix prior to receiving this written confirmation from the Contract Administrator as stated in Clause 1151.04.02.01 of 1151.

SAMPLE LETTER TO CONTRACTOR #2-1

To: ______________________________
(NAME OF CONTRACTOR)

CONTRACT NO.:_________________

Re: Contractor Mix Designation as required by SP for Acceptance of Hot Mix by End Result Specification

Your submission of a mix design and job mix formula documents for item #______, __________ (mix type), dated ____________ has been received and reviewed by MTO.

OPTION #1

This letter is confirmation that the above submission conforms to the Contract requirements and placement of this mix may now commence on this Contract.

Confirmation of conformance to Contract requirements of the submitted Marshall or Superpave mix design, including the mix check by the Independent laboratory, does not constitute any guarantee that the mix can be produced and/or constructed to Contract requirements, and does not relieve the Contractor of the responsibility for ensuring the specified quality of materials and workmanship is achieved.

OPTION #2

The above information does not conform to the Contract requirements for the following reasons:

-
-
-
-
-

A new submission of the mix design and job mix formula documents is required.

The following points were noted in your submission.

-

________________________ ____________
Contract Administrator, MTO Date

cc: Head, Quality Assurance
Originator

2-3 Field Adjustments to the Job Mix Formula

The criteria for making field adjustments to the job mix formula (JMF) have **now** been incorporated **in subsection 313.07.13** of **313**.

Definition

A field adjustment to the JMF is defined as a change in the target gradation and/or asphalt cement content of a mix, within specified limits, without a redesign of the mixture.

Submission

The revised JMF must be supplied in writing, together with supporting documentation to the Contract Administrator. The revised JMF may be applied to the lot being placed at the time the confirmation of the receipt of the revised JMF is issued, and the previous lot, if requested by the Contractor, as part of the written submission for a JMF change. If this request is not made, then the revised JMF will not apply to any mix placed prior to confirmation of receipt of the revised JMF.

A field adjustment is permitted under three different situations (i.e "a-c"), the details of which are given in subsection **313.07.13** of **313**.

Number of Permitted Changes

The number of field adjustments to the JMF is limited to two for each mix design submitted for a given item.

Maximum Permitted Change

Field adjustments must be limited in scope such that the net impact of all of the adjustments does not exceed any of the requirements given in **TABLE 1** (entitled "Maximum Field Adjustments for JMF") of **313**, in comparison to the original JMF submitted under the current mix design.

It should be noted that, if a JMF change results in a decrease in the design asphalt cement content, the lower limit (LL) must now be set at the revised JMF minus 0.3% for all lots to which the JMF applies (see Note 1 beneath Table 6 in 313).

When the job mix formula is changed, it should be documented on the pertinent weigh ticket and/or inspector's diary.

Test Results to Support Request For Field Adjustment

The request for a field adjustment to a JMF, under all situations requires that test results be submitted as supporting documentation (see subsection **313.07.13** of **313**).

A form and its accompanying description, which is included in Appendix D, has been developed for the Contractor, in order to justify changes to the job mix formula. An electronic version of this form is available from the appropriate Regional Quality Assurance Section.

2-4 Lot Size and Sampling

The lot sizes for hot mix will be set at the Contract Administrator's discretion, in consultation with the Contractor. However, when the tender item quantity is 5,000 tonnes or more, the lot size for Aggregate Gradation, Asphalt Cement Content, Air Voids, Compaction and VMA will normally be 5000 tonnes with 10 equal sublots of 500 tonnes each. The number of lots may be chosen in accordance with the guidelines given in **TABLE 4 of 313,** entitled "Breakdown of the Tender Item Quantity Into Lots". Interruptions during paving and tender items with smaller quantities than 5,000 tonnes will be dealt with, as detailed in **313** and this Section.

A set of three samples [see **TABLE 2** of **313** and Notes 1), 2) **and 4)** of Chapter 1 for sample size and frequency] will be taken for each sublot. **Note that sample weight ranges have replaced the simple minimums referred to in previous versions of F34 and S35 and that no single receptacle shall weigh more than 30 kg.**

The Contractor and Owner will each receive one sample to determine compliance for aggregate gradation, asphalt cement content, air voids and voids in mineral aggregates. The third sample from the set of three will be saved by the Owner and designated as a referee sample. For SMA mixes, one additional sample will also be taken from one of the sublots from each lot, which will be split into three (QA, QC and referee) relatively equal portions for determining its draindown characteristics. For each sublot, all samples will be taken from the same truckload and at the same transverse offset. More details regarding the sampling procedures are given in Chapter 1.

A set of three cores will also be taken from each sublot for compaction testing. All cores for each sublot will be taken at the same transverse offset and at a spacing of **1.0 ± 0.1 m** between each core (See Section 1-3 in Chapter 1). The Owner and the Contractor will each receive one core and the third core will be delivered to the Owner and saved for possible re-testing or referee testing.

If the item overruns, the planned lot size should be continued, taking random samples as required until the item is completed. After the samples for the last complete lot have been taken, the additional sublots should be treated in the same manner as for an interrupted lot, as shown in Section 2-4.2.

2-4.1 Paving on Bridge Decks and Staged Construction - All Item Quantities

The quality of hot mix on bridge decks is a major concern to the Ministry because of the severe consequences which can result from substandard material. To address this concern, the Contract Administrator, in conjunction with the Regional Quality Assurance Section, should treat hot mix placed on a bridge deck or placed in staged construction as a separate lot. The Contract Administrator should also consider including paving of the approaches to a bridge as part of the lot.

To determine the amount of testing that will be required **for** that lot, the Contract Administrator must consider the consequences of accepting substandard material, the amount of material to be placed and the constraints (location and work load) of the Acceptance Laboratory. The Contract Administrator may also want to consider the quality of mix that was produced to date using that particular job mix formula.

2-4.1.1 Bridge Decks

For Superpave and SMA mixes on bridge decks, it is suggested that the lot be divided into 3 approximately equal sublots; each with one set of three samples [see **TABLE 2 OF 313** and Notes 1), 2) **and 4)** of Chapter 1 for the sample size and frequency] at each sampling location. Test one of the samples from each of the three sublots and apply the results to the ERS system outlined in the SP and this Chapter.

To determine if the mix is **not** rejectable for the lot, the aggregate gradation, asphalt cement content, air voids and compaction must comply with the limits specified in **TABLE 6 of 313**. Note that, for other mixes, the method described in Clause 2-4.1.2 for construction in stages of less than 100 tonnes may also be used.

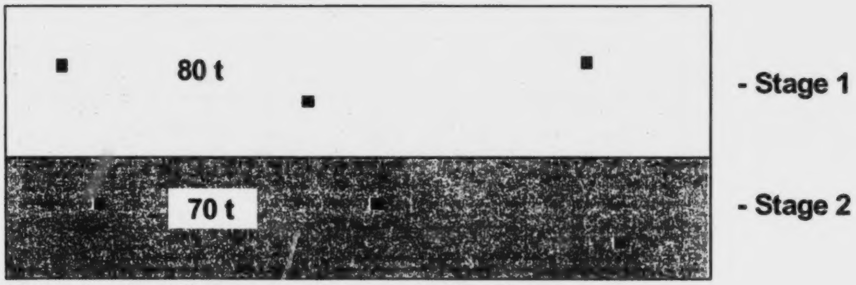
2-4.1.2 Staged Construction

When any construction stage is greater than 100 tonnes, the procedure described in clause 2-4.1.1 for bridge decks should be used.

However, when a construction stage is less than 100 tonnes, it is suggested that the lot be divided into 3 approximately equal sublots, each with one random set of three samples (see **TABLE 2** of **313** and Notes 1), 2) **and 4)** of Chapter 1 for sample size and frequency]. Test one sample from the set of three taken in any one of the three sublots and compare the results with the requirements listed in **TABLE 6 of 313**. If the sample is non-rejectable, then the lot will be paid for at the full contract price and the remaining samples will be discarded. However, if the tested sample is rejectable, then one of the three samples taken from each of the remaining sets of three samples will be tested and the results for all three samples will be applied to the ERS system outlined in the SP and this Chapter.

The following example illustrates the use of Option 2 applied to staged construction.

- **Example: Staged construction**



1. Take 3 sets of 3 samples for a particular stage.
2. One of the 9 samples is tested for acceptance and compared to the rejection criteria outlined in **TABLE 6 of 313.**
3. If non-rejectable - the Contract Administrator may recommend that all remaining samples be discarded. Full payment is given.
4. If rejectable - test one of the 3 samples for each of the remaining 2 sets of three samples and apply the combined ERS system using a separate lot for each stage

Note 1) For contracts **requiring** Contractor testing for acceptance, the Contractor shall perform the above testing and the Owner may perform QA testing on samples from any location.

2-4.2 Item Quantity Greater Than 5,000 Tonnes

When the hot mix tender item quantity for Superpave or SMA mixes is 5000 t or more (3000 t for Open Friction Course), it will be permitted to have one lot not exceeding 500 t and consisting of one sublot. However, it should be noted that, for SMA, this single 500 t lot will be replaced by 2 to 3 trial lots (each divided into 3 sublots) with a total tonnage of up to 1000 t which will be placed in the binder. This 500 t lot must be placed in a binder course (except for OFC or if the contract is single lift construction, where it must be placed in the surface course) and not in a critical location such as a bridge deck and may even be deferred to the next construction season. However, it must never be used to retroactively reduce price adjustments.

To determine if the mix is rejectable for this 500 t lot, asphalt cement content, aggregate gradation, air voids and compaction must comply with the limits specified in **TABLE 6 of 313.** There must be one set of mix samples taken for the mix properties and three cores taken for compaction with n=3 being used to calculate the PWL. This lot will not be subjected to a payment adjustment unless the mix is rejectable. However, when the mix in that lot is rejectable, then the criteria for rejection, repair and payment reduction will apply. The remaining quantity of the tender item, will normally be divided into 5,000 t lots, each with ten equal sublots of 500 t each. Various ways of planning the location of these lots are shown in the examples (in the following pages) .

The quantity remaining after paving the last full lot will normally be treated as follows:

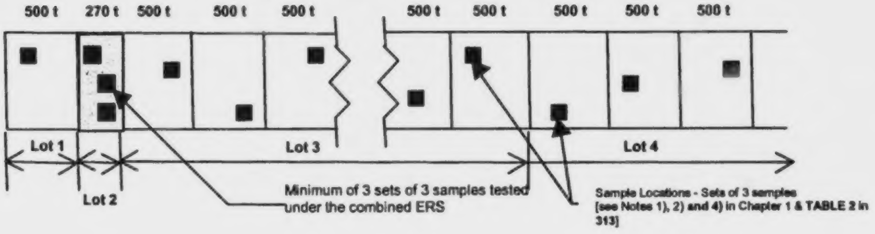
a) If the remaining quantity is expected to be less than 1000 t, consider it as part of the previous lot.

b) If the remaining quantity is expected to be greater than 1000 t, then the Contractor may request that the remaining quantity be considered as a separate lot with a minimum of three sublots.

Examples of the application of the ERS system when the item is greater than 5,000 t are as follows:

Paving of Bridgedecks - Item quantity = 15000 tonnes

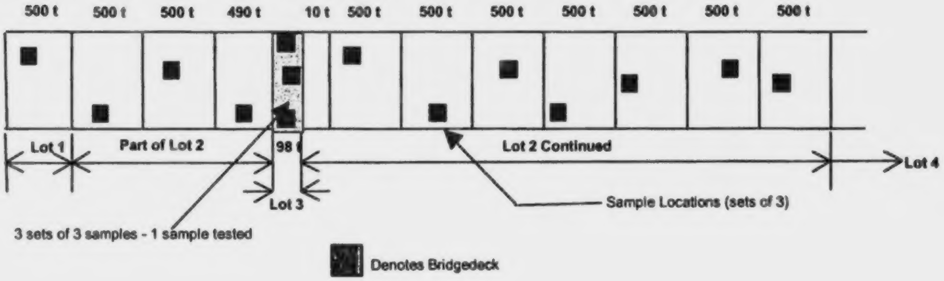
Example 1 - Bridgedeck Quantity >100 t (Paved near start of job)



500 t
270 t
500 t
500 t
500 t
500 t
500 t
500 t
500 t
500 t
Lot 1
Lot 2
Lot 3
Lot 4
Minimum of 3 sets of 3 samples tested under the combined ERS
Sample Locations - Sets of 3 samples [see Notes 1), 2) and 4) in Chapter 1 & TABLE 2 in 313]

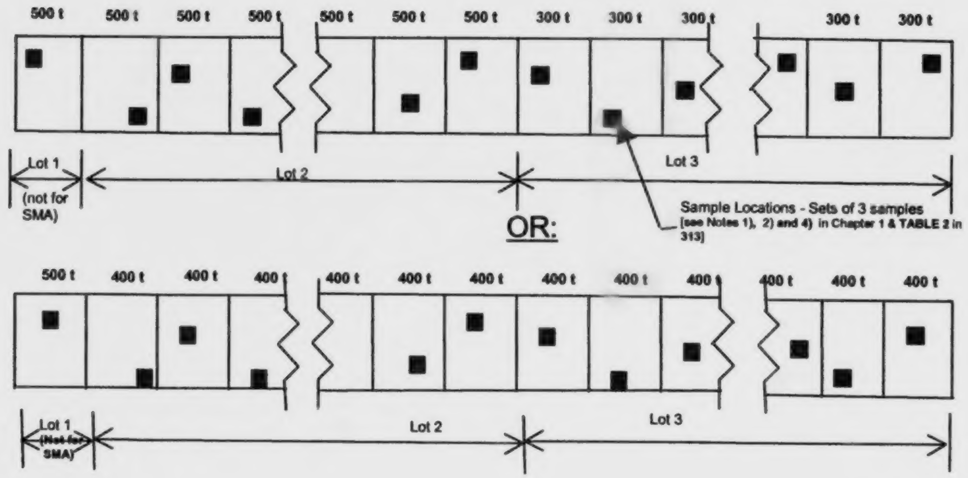
OR:

Example 2 - Bridgedeck Quantity < 100 t (Paved at Middle of



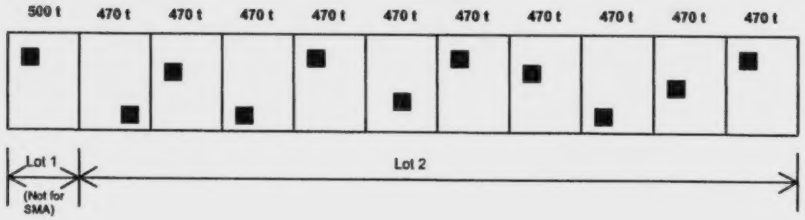
500 t
500 t
500 t
490 t
10 t
500 t
500 t
500 t
500 t
500 t
500 t
500 t
Lot 1
Part of Lot 2
98 t
Lot 2 Continued
Lot 4
Lot 3
Sample Locations (sets of 3)
3 sets of 3 samples - 1 sample tested
Denotes Bridgedeck

Example: Item quantity = 8500 tonnes



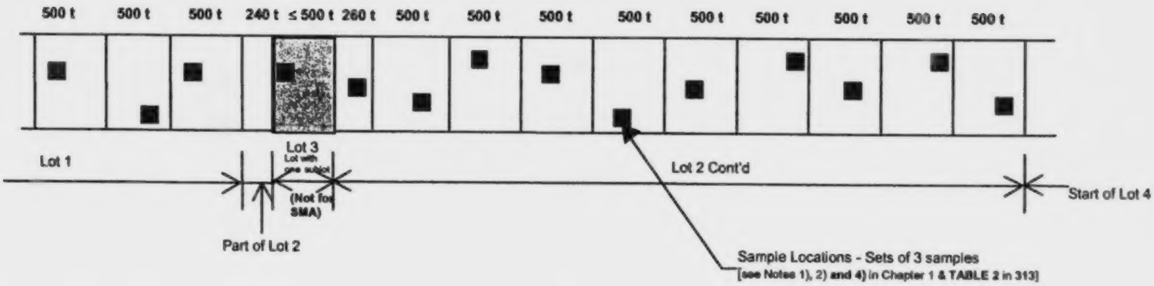
500 t
500 t
500 t
500 t
500 t
500 t
500 t
300 t
300 t
300 t
300 t
300 t
Lot 1
(not for SMA)
Lot 2
Lot 3
Sample Locations - Sets of 3 samples
[see Notes 1), 2) and 4) in Chapter 1 & TABLE 2 in 313]
OR:
500 t
400 t
400 t
400 t
400 t
400 t
400 t
400 t
400 t
400 t
400 t
400 t
400 t
Lot 1
(Not for SMA)
Lot 2
Lot 3

Example: Item quantity = 5200 tonnes



500 t
470 t
470 t
470 t
470 t
470 t
470 t
470 t
470 t
470 t
470 t
Lot 1
(Not for SMA)
Lot 2

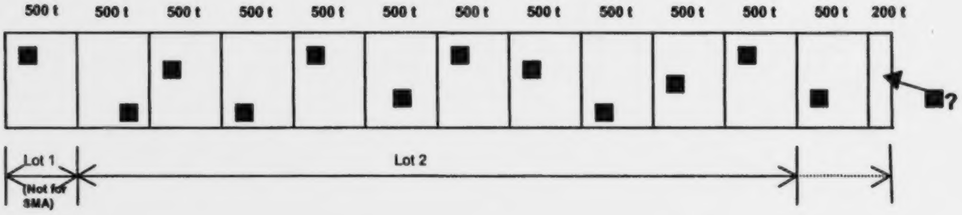
Example: Item quantity > 5000 tonnes



500 t
500 t
500 t
240 t
≤ 500 t
260 t
500 t
500 t
500 t
500 t
500 t
500 t
500 t
500 t
500 t
Lot 1
Lot 3
Lot with one sublot
(Not for SMA)
Part of Lot 2
Lot 2 Cont'd
Start of Lot 4
Sample Locations - Sets of 3 samples
[see Notes 1), 2) and 4) in Chapter 1 & TABLE 2 in 313]

When only one or two sublots are completed at the end of the paving item, due to a change in the job mix formula or when a delay of more than 20 business days occurs in placing the complete lot, then the test results obtained for the one or two sublots will be considered as part of the previous lot and the previous lot will then have eleven or twelve sublots. When three to nine sublots are completed due to the above circumstances, then the three to nine sublots will be considered as a lot. However, when a delay of more than 20 business days occurs in placing the complete lot, prior to the end of the 20 business days, at the Contractor's request in writing to the Contract Administrator, the lot may be completed upon the resumption of paving for that item.

Example: Interrupted sequence of paving due to unforeseen stoppage or change in Job Mix Formula



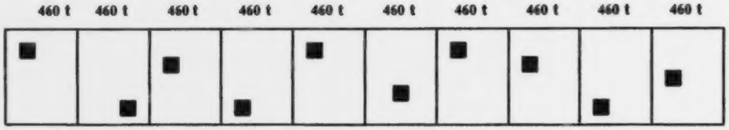
Note: **2)** The last 200 t shown in the diagram (referred to by the "?") would be a sublot if, by random numbers, a sample was required to be taken. Regardless of whether or not a sample is to be taken, the 200 t is included in the total quantity of the previous lot.

2-4.3 Item Quantity 1,000 Tonnes to 5,000 Tonnes

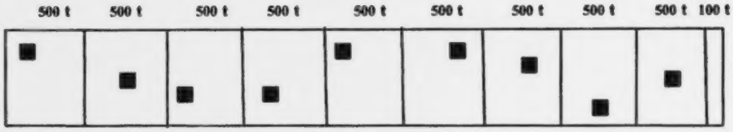
When the tender item quantity is between 1000 t and 5,000 t the quantity will normally be considered as one lot. The lot/sublot sizes can be reduced at the discretion of the Contract Administrator and after discussion with the Contractor. If possible, the sublot sizes should be of equal size. A minimum of three sublots have to be completed and tested to constitute a lot in order that the ERS system may be used.

An example of the use of the testing regime to be used is as follows:

Example: Item Quantity = 4600 tonnes



NOT



2-4.4 Item Quantity Less Than 1000 Tonnes

When the item quantity is less than 1000 t, the lot/sublot sizes will be determined by the Contract Administrator based on individual circumstances. For item quantities less than 1000 t, the hot mix may be accepted by the Contract Administrator based upon such testing as is deemed necessary by the Contract Administrator to determine substantial conformance with the contract. When three or more tests have been completed, for a lot, the material will be accepted at the full contract price, subjected to a payment reduction or rejected, as detailed in the special provision.

The amount of testing to be performed on a lot will depend on the consequences of accepting substandard material, the amount of material to be placed and the constraints (location and work load) of the Acceptance Laboratory.

2-5 Density Testing and Reporting of Results

2-5.1 Density Testing of Hot Mix Aggregates and Calculating VMA (for Contracts Where QC Test Results Are Used for Acceptance)

For contracts **where QC test results are used for acceptance,** the Contractor must report the QC density testing of aggregates and RAP which was done for the purpose of developing mix designs for each mix type in the Contract. The testing may be performed during the production of each aggregate and RAP (if RAP is included in the mix) or during the stockpiling of the materials at the hot mix plant.

During HMA production, the Contractor is required to procure samples **for Recycled Asphalt Pavement (RAP), New Roof Shingle Tabs (RST) and the aggregates identified in the mix design, in accordance with clause 313.07.15.02 of 313**, conduct density tests for RAP and each aggregate identified in the mix design for each mix type, and report the resulting combined aggregate densities.

The calculation of QC VMA is based on the process control bulk relative densities of aggregates obtained during the mix design process, or the values that are submitted with the revised mix design, as permitted in the specification, averaged with the determination of densities on the specified QC samples obtained during HMA production. For QA purposes, the calculation of VMA is based on testing carried out on samples submitted with the mix design, or the revised mix design if applicable, averaged with the determination of densities on the specified QA samples obtained during HMA production. For both QC and QA, results for aggregate density test results for samples taken during HMA production are applicable only to the lots subsequent to the lot during which they were taken. The conditions for referee testing are given in Subsection 2-7.2.1.

To improve the test methods and facilitate the contract adminstration of VMA, the following changes were introduced last year in SP 103S34 which are also included in 313:

a) The first set of aggregate and RAP samples must be taken within 10 days prior to the start of production for the first lot of hot mix. Subsequent samples will then be taken immediately following the completion of 15,000 tonnes and at intervals of 20,000 tonnes of hot mix, thereafter.

b) The calculation of VMA will now be based on the densities of the blended coarse and the blended fine aggregates (instead of mathematically combining the densities of the individual aggregates for the coarse and fine).

c) **The individual** VMA's will now be calculated to two decimal places **but the lot mean will only be calculated to one decimal place** .

d) For the aggregate density testing, if the difference between QA and QC testing is less than or equal to 0.010, then the QC value will be used for calculating VMA. However, when that difference is between 0.011 and 0.020, the value used will be the mean of the two. Referee testing will only be invoked, when the difference between the QA and QC values is greater than 0.020.

2-5.2 Reporting Test Results

The ERS system requires that the test results from a number of sublots be used to determine the acceptability of a lot with the exception for the lot with one sublot (or for SMA, the 2 to 3 trial lots in the binder which replace the lot with one sublot) which is allowed for an item with greater than 5000 t.

As the QC tests are completed and received by the Contract Administrator, the QA test results for each sublot can be made available to the Contractor. However, no indication is to be made as to the acceptability or otherwise of the hot mix, based on these individual results.

The test results from the extraction tests, compaction testing and air voids from each sublot are used to determine a combined payment factor. For lots with 3 or more sublots, a computer program has been developed to calculate the combined payment adjustment based on all applicable attributes (see Chapter 3.0). An example of the form entitled "**ERS 2007 - Hot Mix QC/QA Comparison and Payment Factor Calculation**", which is generated from such calculations, is shown at the end of this Subsection.

2-6 Acceptance

The "Combined" ERS bases the acceptance of hot mix on a lot-by-lot basis. Aggregate gradation of four sieves (i.e. the "designated large sieve", the 4.75mm, 600µm and 75µm sieves), asphalt cement content, air voids, VMA and compaction are accepted based on the percent within limits (PWL) of the lot. An example is given at the end of this Chapter.

For **most** contracts, which **use QC test results for acceptance**, the Contract Administrator will determine the acceptability of the mix based on test results generated by the Contractor, provided that those test results meet the requirements for the comparison of QA and QC results. For Superpave and SMA mixes, the Contractor will test one sample for A.C. content, aggregate gradation, the percent air voids, and voids in the mineral aggregate. One core from each sublot will also be tested by the Contractor to determine Percent Pavement Compaction.

For **all other** contracts which contain SP 103S35, the Contract Administrator will determine the acceptability of the mix based on the Owner's test results. The Owner will test one (plate) sample for the attributes described in the previous paragraph.

The mean and standard deviations of the test results for each attribute measured from samples taken from each sublot are calculated according to the following formulae:

$$\bar{X} = \frac{\sum x_i}{n} \quad (1)$$

$$s = \sqrt{\frac{\sum\left(x_i - \bar{X}\right)^2}{n-1}} \quad (2)$$

Where: $\overline{X}$ = the lot mean, s = the sample standard deviation

x_i = the individual value or test result

and n = the number of samples in the lot

The Percent Within Limits (PWL) for each attribute is then calculated based on the appropriate lower and upper specification limits (LL and UL, respectively) given in **TABLE 6 and TABLE 7 for SP 12.5 FC2** of **313** and the formulae and **associated** Table 1, given in Appendix C.

The payment factors for the all of the different attributes are then combined together to obtain the Total Payment Factor for each lot according to the method and equations outlined in **Clause 313.10.01.02** of **313 (with appropriate modification where S35 is included in the contract)**. An example can be found at the end of this Chapter.

For SMA Only

For SMA only, the percent within limits calculations for air voids will be carried out for information purposes only.

It has been agreed with Industry that, until more experience is gained with SMA, an interim Air Voids Administration Procedure will be in place. In this procedure, a lot will be considered acceptable with respect to air voids, if the mean of the test results for that lot is greater than or equal to 2.5% and less than or equal to 5.5%, as long as no individual test result for a sublot is less than 2.0% or greater than 6%. A lot will be considered rejectable, if the mean of all of the test results within that lot is either less than 2.5% or greater than 5.5%, while an individual sublot will be considered rejectable, if its test result is less than 2.0 percent or greater than 6.0 percent air voids.

In addition for SMA, the Contractor will also be required to test one sample from each lot (i.e. the additional 10 kg sample chosen from one of the sublots) to determine its "Draindown" characteristics. If either the QC or QA samples are found to exceed the 0.3 percent requirement for this test, then the referee sample will also be tested for information purposes. Again this year, if the mix exceeds the 0.3 percent requirement but does not initially indicate the presence of "fat spots", the mix will not be removed but will be monitored for performance. However, if such fat spots begin to develop at a later time then they will be treated as any other visual deficiency (see Section 5-2).

2-7 Re-testing For Outliers / Referee Testing

Either the Contractor or the Ministry may challenge the validity of one of the results within a lot as an outlier.

For contracts containing SP 103S35, the Contractor or the Owner may challenge one, two or all sublots from a lot through referee testing. However, for **all other** contracts **where acceptance is based on QC testing**, challenges may only be settled by referee testing of all sublots. Details of these mechanisms are included in the following subsections.

2-7.1 Challenging an Individual Test Result as an Outlier

The Contractor or the Contract Administrator may question an individual test result from the original (i.e. first) set of results only when the payment factor for that lot is less than 1.0. VMA is excluded from outlier challenges. The challenge must be made within three (3) business days of the Contractor and Contract Administrator having received all of the test results for that lot.

When the result from one of the tests is challenged as an outlier, the "T" test is used to determine whether the result is either typical of or is not typical of the population. If it is not typical of the population, then it is considered to be an "OUTLIER" and may be replaced with another test result. The identification of an outlier does not mean that the sampling or testing was performed incorrectly but only that it is not typical of the lot.

Outliers are identified through the principles of a normal distribution curve (i.e. values that are at the outside edges of the "bell curve" are unrepresentative of the group mean). A 10% significance level [see Note 5) given later in this Chapter] is used for the "T" test.

The precision that should be used for recording individual test results and the lot mean and standard deviation which are used to calculate the "T"-values used in the "T" test are shown in Table 2-1.

Table 2-1 - Precision to Be Used When Conducting a "T" Test

Parameter	Individual test results	Lot Mean	Lot Standard Deviation
Aggregate Gradation (%)	1 decimal place	3 decimal places	4 decimal places
Asphalt Cement Content (%)	2 decimal places	3 decimal places	4 decimal places
Air Voids	1 decimal place	3 decimal places	4 decimal places
Pavement Compaction (%)	1 decimal place	3 decimal places	4 decimal places
Final Calculation for "T"	3 decimal places	3 decimal places	3 decimal places

Note: 3) When conducting the "T" test, all rounding should conform to LS-100 (given in Appendix C).

Two examples illustrating the use of the "T" Test, Table 2-2 ("Critical Values for the "T" test) and the required precision (Table 2-1) are given below:

Examples from Extraction Test Results

Example 1 Lot No. 4

Sublot No.	AC content (%)
1	4.65
2	4.82
3	4.93
4	4.75
5	4.86
6	*5.18*
7	4.63
8	4.99
9	4.81
10	4.63

An inspection of the ten test results, shown in Example 1, might suggest that the asphalt cement content value of 5.18 % for sublot 6, may not come from the same population as the asphalt cement contents determined from the samples taken from the other nine sublots. In order to test this hypothesis, it is first necessary to determine the mean $\overline{X}$, and standard deviation, s for the ten values:

$$\overline{X} = 4.825; \qquad s = 0.1758$$

In order to avoid negative numbers, the absolute value of the difference between the value being tested and the mean of all of the test values is used in equation (3) for m=6:

$$(3) \qquad T_m = \frac{\left|X_m - \overline{X}\right|}{s}$$

$$T_6 = \frac{\left|5.18 - 4.825\right|}{0.1758} = 2.019$$

From Table 2-2, for n = 10 (i.e. for ten test results), we observe that the upper 5 % Significance Level is 2.176. Since 2.019 is less than or equal to 2.176, it is reasonable to conclude that the value of 5.18 is not significantly high and that there is a very good chance that it comes from the same population as the other nine values.

Table 2-2 - Critical Values for the "T" Test When the Standard Deviation is Calculated From the Same Sample

Number of Observations	10% Two-Sided Significance level (Upper or Lower 5% Significance Level)
3	1.153
4	1.463
5	1.672
6	1.822
7	1.938
8	2.032
9	2.110
10	2.176
11	2.234
12	2.285

Example 2 Lot No. 8

Sublot No.	% <4.75mm sieve
1	51.0
2	*62.8*
3	54.6
4	52.1
5	55.8
6	53.2
7	49.7
8	50.9
9	55.6
10	53.8

An inspection of the ten results, shown in Example 2, suggests that the value of 62.8 % for sublot 2 may not come from the same population as the other values. The mean of the ten values, $\overline{X}$ = 53.950 and the standard deviation, S = 3.7263 From these values, we therefore compute T_2 for sublot 2:

$$T_2 = \frac{|62.8 - 53.950|}{3.7263} = 2.375$$

From Table 2-2 for n = 10, we observe that the lower 5 % Significance Level is 2.176. Since 2.375 is greater than 2.176, it is reasonable to conclude that the value 62.8 for sublot 2 is not likely to have come from the same population as the other nine values. Further investigation of the doubtful value is, therefore, warranted.

If the outlier test procedure indicates that the test result is not valid, then the result will be discarded, unless there is an obvious error in the calculations or in the transposing of the numbers. If there is no obvious error, then the third sample from the set of three (or third core from the set of three) will be tested. The sample will be tested by the Contract Administrator or the Contractor (depending upon which SP is in the Contract (See Subsection 2-7.2) and the results used in the calculations for payment adjustments will be binding on both the Contractor and the Owner.

Notes: 4) There may be cases where the precision of intermediate steps (i.e mathematical operations on individual test results) required for final calculation of a "T" value may not be clearly stated either within the Contract or this Field Guide. As a result, the Contractor's calculations for the "T" test may be based on slightly different assumptions of precision for these intermediate steps than the calculations carried out by the Ministry's representative. Where this is the case, the Contractor's calculations should be accepted, provided that he has used the appropriate precision and rounding procedures wherever they have been specified.

5) The Ministry 's position is that outliers could occur on either side of the mean value but not on both sides simultaneously. The maximum risk of erroneously rejecting a result which comes from the same population as the other values (i.e. the significance level) is set at 10%. This means that values on the outside 10% of the population are considered to be outliers. This significance level (two-sided) is the same as a 5% significance level on the low side and a 5% significance level on the high side.

6) For contracts containing 103S35, the results from outlier testing will be used for any subsequent referee challenges involving the same sublot. Therefore, if the referee sample is tested for an outlier of Asphalt Cement, Gradation, or Air Voids, the sample will also be tested for the other two criteria in case the results are needed for a subsequent referee challenge.

7) For contracts **where acceptance is based on QC testing**, the replacement result for the outlier may be obtained from the Owner's result for the affected sublot if the owner tested that sample, or the Contractor can test the referee sample and forgo referee privileges for the affected lot.

2-7.2 Referee Testing

Depending upon the conditions described in **313 or SP103S35, whichever is appropriate**, referee testing may be requested. If referee testing is invoked, then the referee laboratory will be selected by the Contract Administrator from a Roster Rotation List, which is maintained by the Owner for this purpose. This list has Regional zones which allows local laboratories to participate in the process and reduce the transportation distance that some samples must traverse (particularly from contracts in the Ministry's Northeastern and Northwestern Regions).

The Contract Administrator will be responsible for the delivery of the referee samples to the selected laboratory. Both parties will be permitted to observe the testing. Most referee laboratories have specific protocols for observing their testing which should be adhered to.

The referee test results will be binding on both the Contractor and the Owner and no further testing will be done except that, when repairs are carried out, the lot will be re-evaluated as specified under "Repairing and Re-evaluating".

2-7.2.1 Contracts Where QC Test Results Are Used for Acceptance

For contracts **where QC test results are used for acceptance**, testing by an independent third party referee is available to assess the quality of hot mix, regardless of the differences in the test results generated by the Quality Control and Quality Assurance laboratories.

The Owner or Contractor may invoke referee testing of the entire lot within 5 business days of the Contractor receiving the Contract Administrator's calculated QC and QA payment factors for the lot for the conditions described in clause **313.08.01.02.04 and TABLE 8** of **313**. In addition, for SMA, either party can request referee testing for draindown.

Referee Testing for VMA

For Contracts **where QC test results are used for acceptance**, when the combined aggregate density determined by a QA laboratory is within 0.020 of the mean combined aggregate density used by the QC laboratory, the aggregate densities will be deemed to be in agreement and the referee laboratory must use the mean QC combined aggregate density in calculating the VMA. However, if the mean QC and QA combined densities are not in agreement, then the referee laboratory must conduct aggregate density testing on samples supplied to it for this purpose. These samples must be the last samples taken prior to the start of the lot being subjected to referee testing. The combined aggregate density result must be compared to the mean QC and QA combined aggregate density results, and the referee calculation of VMA must be based on the result which is closer to the referee result or the referee result itself, if it is exactly in between the QC and QA combined aggregate density test results.

2-7.2.2 Contracts Containing SP 103S35

For contracts containing SP 103S35, the Contractor or the Contract Administrator can request referee testing for one sublot per lot, two sublots per lot or an entire lot. In addition, for SMA, either party can request referee testing for draindown only.

Referee testing, for a given lot, can be invoked within 5 business days of the Contractor receiving the Contract Administrator's calculated payment factors for the lot. Referee testing may be invoked under the conditions given in **Table 8 of 313** and described in Subsection **313.08.01.02.04 of** 313, as amended by **S35**. However, before it is decided to go to referee testing, it is recommended that the Senior Engineer in the Bituminous Section at Head Office, who is responsible for the applicable Region, be contacted at (416)-235-3715.

2-7.2.3 Outliers in Referee Results

For Superpave and SMA mixes, when an outlier is identified in referee test results, then the sublot containing the outlier will be treated as a lot with one sublot for both mix properties and compaction (or air voids, when only air voids is subject to referee testing, and compaction for SMA). The remaining sublots will then form a separate lot. There will also be a 50/50 cost sharing between the Owner and the Contractor for referee outlier testing, as stated in the SP.

2-8 Repairing and Re- Evaluating

The Contract Administrator **may** require that a rejectable lot be repaired or the Contractor **may elect** to carry out repairs in lieu of accepting a payment adjustment, **if the lot is not rejectable and the total payment factor for the lot is less than 0.940.**

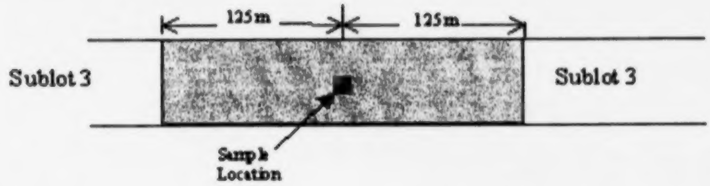
Whenever repair work is to be carried out, the Contractor has to determine the area(s) to be repaired. However, the Ministry will determine where the original sublots actually started and ended using weigh ticket information and/or diary records. The Ministry should not give any advice regarding the areas to be repaired other than ensuring that all pertinent test information is available to the Contractor on request. The Contractor should be permitted to undertake additional testing at no cost to the Ministry, if the Contractor wishes, in order to verify the extent of the rejectable material.

This year, the Contractor is required to submit a list and sketches identifying the proposed locations of the repairs to the Contract Administrator, at least 5 business days prior ot the intended start of the repair work in accordance with clause 313.08.01.02.06 of 313. Each repair area must:

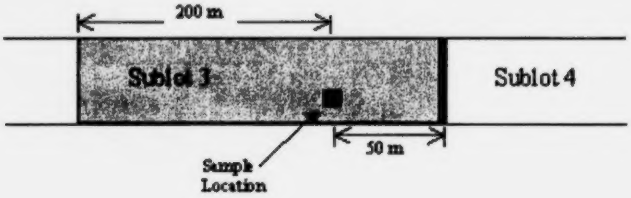
1) **Include at least one of the loose mix or core sample locations;**
2) **Be a minimum length of at least 250 lane-metres or, if a repair extends into another lane, no portion of a single lane repair can be less than 125 m;**
3) **Be separated by at least 100 m, otherwise the separated repair areas must be combined into one continous repair; and**
4) **Repairs must be in increments of 25 m.**

Some typical examples of repair areas (shown as grey plus the hatched areas, if applicable) are included below:

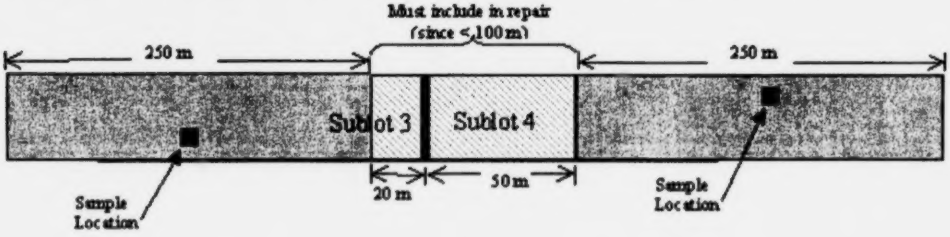
a) Typical Sublot Repair



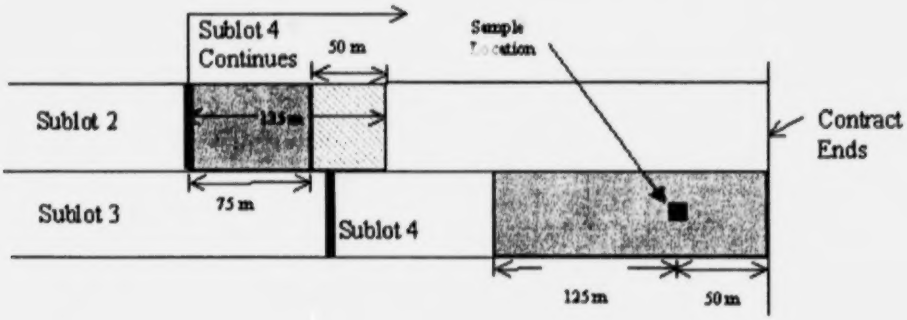
b) Sublot Repair Near End of Sublot


200 m
Sublot 3
Sublot 4
50 m
Sample Location

c) Repairs in Two Adjacent Sublots That Are Separated by Less than 100 m


Must include in repair (since <100m)
250 m
250 m
Sublot 3
Sublot 4
20 m
50 m
Sample Location
Sample Location

d) Repairs Which Extend into an Adjacent Lane


Sublot 4 Continues
50 m
Sample Location
Sublot 2
125m
Contract Ends
Sublot 3
75 m
Sublot 4
125m
50m

Both ends of each repair area **that are** selected by the Contractor must be extended by one metre **and a** slab sample or clusters of cores **must be taken from these extended areas** to provide sufficient material for the testing that is required for A.C. content, Gradation and Air Voids and/or Compaction. **The test results for these samples will be used to determine if the mix within those extended ends is within the specified limits given in Table 6 of 313 for non-rejectable material. If the mix still turns out to be rejectable, then the Contractor will be required to extend the repair area by a minimum of 25 m (plus the additional metre at each end) before re-sampling and re-testing begins again.**

Once the repairs **have been** made to all or part(s) of a lot, **two separate lots** will be re-evaluated.

One lot will include the unrepaired sublots plus the remainder of the repaired sublots. That lot will be assessed on the basis of the loose mix or core samples or both the loose mix and core samples representing the unrepaired sublots. However, if there are only one or two sublots in a lot **that** are not repaired, then the Contract Administrator will include those sublots as part of the previous or next lot. **If the referee laboratory has tested the lot, then the referee test results will be used to determine the payment factors instead of the original test results.**

The second lot will normally consist of the mix used for the repair itself, unless the Contract Administrator and the Contractor have agreed to include it as part of the current lot being produced. The repaired areas will be tested for all criteria.

2-9 Mixes That Are Difficult to Compact due to "Unmanageable Factors":

In the past, the ORBA have presented concerns to the MTO related to a Contractor's ability to deal with "Unmanageable Factors" which may effect compaction but are beyond the Contractor's control during the paving operation. Unmanageable factors include such things as:

- areas that are unable to provide adequate support for the compaction operations (possibly due to poor subgrade conditions) or;
- changes in substrate conditions within the same lot (e.g. granular base, unmilled hot mix, milled hot mix), that cause an increase in the lot standard deviation.

Note that the weather is uncontrollable but not unmanageable because Contractors are able to reschedule work/change operations accordingly.

The following interim procedure was developed by the Bituminous Section to determine if there are "Unmanageable Factors" and then, if they are found to be unmanageable, to waive the payment reduction on the affected lots. The procedure was included in a memorandum, dated February 20, 1996 to the Managers of Construction.

1.0 Initial Notification

The Contractor shall notify the Contract Administrator with supporting Process Control test results immediately upon becoming aware of an apparent unmanageable factor(s) but no later than 1 business day of receiving MTO test results for the lot. The Contractor may also request that the lot be re-tested and he shall be notified when re-testing will take place.

2.0 Quality Control Documentation Submission Review

The Contractor shall submit a report within 2 days of the initial notification containing the following:

- the production rates and mix temperatures (discharge and road) for each day of paving;
- all process control results with corresponding MTO results for all lots placed prior to the lot(s) in question;
- the details of the rolling patterns, weights, types and OPS classification of the compaction equipment that was used for all lots;
- details of the daily weather during paving;
- the type and condition of the substrate(s) on which all the lots were placed;
- any other relevant mix, aggregate, or production and placement information and;

- a clear and concise statement of the Contractor's opinion on what factor(s) was unmanageable and how this affected the test results.

The report shall be a well-organized document with charts or other data summaries to illustrate the Contractor's position and shall clearly lay out the steps that he has taken to improve and detail the results achieved.

The Ministry will review the submission for completeness and advise the Contractor if the submission is incomplete. If the submission is incomplete, then the Contractor can resubmit the report with additional documentation to continue the appeal or he can abandon the appeal.

The report will be made available to a mutually agreed upon advisor, if one is needed.

3.0 Independent Compaction Advisor

The Contractor or the Contract Administrator, in conjunction with the Quality Assurance Section and the Bituminous Section, shall determine whether a mutually agreed upon independent compaction advisor will be needed to help with the review. The fees for the advisor shall be equally shared by the Contractor and the MTO.

The advisor shall assist by reviewing and recommending changes to the Contractor's operation and/or mix design and discuss the probable reason(s) for the poor compaction. The MTO decision will be as outlined in Section 5.0.

4.0 Field Demonstration Review

When the Contractor notifies the Contract Administrator that there is an apparent unmanageable factor, the MTO will arrange to review the paving and compaction operations of the mix.

Prior to the review, a meeting shall be held to discuss how, what, when and where the demonstration and review will be done. The purpose is to agree on production rates, mix temperatures, equipment options, etc. The meeting shall be attended by representatives of the Contractor (with his Subcontractors as desired), the Contract Administrator, the Quality Assurance Section, the Bituminous Section, and the independent compaction advisor, if applicable.

The Contractor shall demonstrate the use of different equipment, rolling patterns, mix temperatures and production rates for a period not to exceed the lessor of 1 day or a quantity of 1500 t.

The demonstration shall attempt to duplicate as closely as possible the weather, substrate and all other conditions that existed when the poor results were achieved provided these conditions met the Contract requirements.

The Contractor shall co-operate with MTO, or a mutually agreed upon advisor, to try different rolling patterns, mix temperatures, production rates or equipment recommended by the MTO or the advisor. The contractor is not expected to provide compaction equipment beyond that outlined in Table V of OPSS 313 for the demonstration.

The MTO will accept the Contractor's process control results for the demonstration only if the results have been comparable to MTO's results on the previous lots. Otherwise MTO will require that the Contractor take cores and pay for MTO testing. The Contractor shall submit the process control results to the Ministry and the advisor (if involved) within one business day of completion of the field demonstration.

The application of the ERS for compaction will be suspended for the demonstration. It shall be applied for lots prior to and after the demonstration, if no unmanageable factor is proven.

The advisor (if applicable) shall submit a brief report on the details and findings of the field demonstration to all representatives who attended the field demonstration review meeting within 3 business days of completion of the field demonstration.

5.0 MTO Decision

The MTO will review the information submitted by the Contractor, together with the MTO's own records and the report of the advisor, if applicable. The MTO will give its decision and reasons within 10 business days of receipt of a complete submission of the documentation from the Contractor. During this period, the Contractor has the option to continue paving at his own risk.

An unattributed brief summary of the findings of each appeal is to be distributed to ORBA and the Regional Managers of Contracts by the Bituminous Section within three months of the decision. It is expected that this information will be shared by ORBA throughout the industry and communicated at the MTO/Contractor prework/prepave meeting.

Note: 8) The MTO considers it critical that the Contractor provide "Evidence" in the form of both documentation and a field demonstration, in order for the appeal to be successful. In the event that a field demonstration is not possible on MTO work, the MTO may accept a demonstration on work done for others with the same mix. If this is not possible, the documentation alone may be deemed inconclusive or insufficient and the price reduction will not be waived.

2-10 Calcium Chloride

When a Contractor suspects that the placement of calcium chloride prior to hot mix paving will prevent the placement of durable hot mix, the Contractor can submit a written request for the Ministry to review the problem on a site-specific basis.

2-11 Example Calculations for Percent Within Limits and Combined Payment Factors

This section presents an example of how to calculate a payment factor based on percent within limits calculations using compaction data from the following example for Superpave 12.5. This example, entitled, "ERS 2007 QC/QA Comparison and Pay Factor Calculation" was determined from the EXCEL® computer program described in Chapter 3.

ERS 2007 - Hot Mix QC/QA Comparison and Pay Factor Calculation

QC LOT PAY FACTOR CALCULATION

April 25, 2007 version

CONTRACT	2007-xxx	Lot No.	4
HIGHWAY	x	Lot Size (t)	5000
REGION	Eastern	No. Sublots	10
MIX TYPE	**SUP125**	Date Paved	15-Jul-07
ITEM No.	3	Date Tested	19-Jul-07

Layer: Surface

The Mean Combined Aggregate Density	2.655
JMF's LL for %AC (select applicable value)	**0.4**

Sublot Data Input

JMF Id.	DLS	4.75 mm	600 μm	75 μm	AC	Air Voids	Compaction	VMA
2007-xxx-xx	**73.5**	**51.8**	**22.1**	**3.8**	**4.60**	☒	☒	**14.0**
Sublot 1	78.9	54.5	24.4	3.9	4.37	4.2	94.6	15.05
Sublot 2	76.3	55.9	25.1	4.1	4.27	4.0	92.8	14.84
Sublot 3	76.3	54.1	24.6	1.9	4.37	4.0	93.0	14.56
Sublot 4	69.9	45.3	21.4	3.7	4.15	4.3	93.5	14.90
Sublot 5	77.7	54.7	24.8	4.2	4.39	3.8	92.3	14.75
Sublot 6	73.1	50.7	23.3	4.1	4.30	3.8	92.8	13.90
Sublot 7	78.7	55.1	24.3	2.8	4.79	3.7	92.3	13.85
Sublot 8	78.0	57.3	25.3	4.4	4.39	2.8	92.6	14.45
Sublot 9	76.1	54.8	24.6	4.4	4.43	3.7	92.5	14.70
Sublot 10	68.8	46.9	21.4	3.1	4.11	4.6	94.5	14.22
Sublot 11								
Sublot 12								

Lot Calculation Results

COUNT	10	10	10	10	10	10	10	10
Lot Mean	75.4	52.9	23.9	3.7	4.36	3.9	93.1	14.5
Std Dev	3.60	3.98	1.43	0.82	0.19	0.48	0.85	0.41
LL	68.5	46.8	18.6	1.8	4.2	2.5	91.5	
UL	78.5	56.8	25.6	5.8	5.1	5.5	97.0	
QL	1.91	1.54	3.72	2.28	0.85	2.90	1.88	
QU	0.87	0.97	1.17	2.62	4.00	3.36	4.62	
PL	99	95	100	100	80	100	99	
PU	81	84	89	100	100	100	100	
PWL	80	79	89	100	80	100	99	
PF	0.9860	0.9830	1.0000	1.0025	0.960	1.020	1.024	1.000

Calculation of Total Pay Factor

PF_g(sub) =	3.9715
PF_g =	0.9929
PF_{gac}(sub) =	1.9529
PF_{gac} =	0.9764
PF_{voids} =	1.0200

$PF_{gac/voids}$(sub) =	1.9964
$PF_{gac/voids}$ =	0.9982
PF_{total}(sub) =	2.0222
PF_{total} =	**1.0222**

Ministry Rep. Signature ______________________

Date: ______________

Contractor Rep. Signature ______________________

Date: ______________

Comments: ____

Acceptance based on QC results is subject to review of QA results by Owner.

Copy to: Regional Quality Assurance Contract Administrator Contractor Originator

1) Percent Within Limits Calculation

Compaction Data For Superpave 12.5 Mix

94.6	92.8	93.0	93.5	92.3
92.8	92.3	92.6	92.5	94.5

(i) Calculate Mean; $\overline{X}$ and Standard Deviation; s of above data using Equations (1) and (2), respectively:

(1a) $$\overline{X} = \frac{\sum x_i}{n}$$

(1b) $$s = \sqrt{\frac{\sum\left(x_i - \overline{X}\right)^2}{n-1}}$$

Where: $\overline{X}$ = the individual compaction value
and n = the number of samples in the lot

$$\text{Mean, } \overline{X} = \frac{94.6 + 92.8 + \ldots\ldots + 94.5}{10} = 93.1$$

$$\text{Standard Deviatiion, } s = \sqrt{\frac{(94.6-93.1)^2 + (92.8-93.1)^2 + \ldots + (94.5-93.1)^2}{9}}$$

$$= 0.85$$

(ii) Calculate the Quality Indices, Q_L and Q_U From the Equations given in Section 5.1 of Appendix C, using the Lower Quality Limit LL and Upper Quality Limit UL From TABLE 6 (for pavement compaction) of 313:

$$Q_L = \frac{\overline{X} - LL}{s}$$

$$= \frac{93.1 - 91.5}{0.85} = 1.88$$

$$Q_U = \frac{UL - \overline{X}}{s}$$

$$= \frac{97.0 - 93.1}{0.85} = 4.59$$

where: Q_L = Lower Quality Index Q_U = Upper Quality Index
LL = Lower Limit UL = Upper Limit

(iii) From Table 1, given at the end of Appendix C , first determine P_L and P_U for n=10 and then select the next highest values:

$P_L =$ 99 From $Q_L = 1.88$

$P_U =$ 100 From $Q_U = 4.59$

(iv) From the Equation given in Section 5.2 of Appendix C, determine the Percent Within Limits (PWL):

$$PWL = (P_L + P_U) - 100 = 99$$

(v) From Table O at the end of the SP for Compaction, the Payment Factor is determined to be 1.024

2) Determining Combined Payment Factor

Payment factors for Superpave 12.5 Mix (From the Same Example)

PF_{AC}	=	Payment Factor for Asphalt Cement	=	0.9600
PF_{DLS}	=	Payment Factor for Designated Large Sieve	=	0.9860
$PF_{4.75}$	=	Payment Factor for the 4.75mm sieve	=	0.9830
PF_{600}	=	Payment Factor for the 600μm sieve	=	1.0000
PF_{75}	=	Payment Factor for the 75μm sieve	=	1.0025
PF_{AV}	=	Payment Factor for Air Voids	=	1.0200
PF_{C}	=	Payment Factor for Compaction	=	1.0240
PF_{VMA}	=	Payment Factor for Voids in the Mineral Aggregate	=	1.0000

(a) Gradation

For Superpave 37, Superpave 25, Superpave 19, Superpave 12.5, Superpave 12.5FC 1, Superpave 12.5 FC 2, SMA 19 and SMA 12.5, from Formula (2) in 313, Calculate $PF_{G(SUB)}$

$$(2)\quad PF_{G(SUB)} = PF_{DLS} + PF_{4.75} + PF_{600} + PF_{75}$$

$$= 0.9860 + 0.9830 + 1.0000 + 1.0025$$

$$= 3.9715$$

Calculate PF_G from Fomulae (3) or (4) in 313:

(3) If $PF_{G(SUB)}$ is greater than or equal to 4, then $PF_G = PFG_{(SUB)} - 3$

(4) Since $PF_{G(SUB)}$ is less than 4, then, $PF_G = PF_{G(SUB)}/4$

$$= 3.9715/4 = 0.9929$$

For Superpave 9.5, Superpave 4.75 and SMA 9.5, from Formula (5) in 313, Calculate $PF_{G(SUB)}$:

(5) $$PF_{G(SUB)} = PF_{4.75} + PF_{600} + PF_{75}$$

Calculate PF_G from Formule (6) or (7) in 313:

(6) If $PF_{G(SUB)}$ is greater than or equal to 3, then $PF_G = PFG_{(SUB)}-2$

(7) If $PF_{G(SUB)}$ is less than 3, then, $PF_G = PF_{G(SUB)}/3$

(b) Combined Gradation And Asphalt Cement Content

From Formula (8) in 313, Calculate $PF_{GAC(SUB)}$:

(8) $$PF_{GAC(SUB)} = PF_G + PF_{AC}$$
$$= 0.9929 + 0.9600 = 1.9529$$

Calculate PF_{GAC} from Formulae (9) or (10) in 313:

(9) If $PF_{GAC(SUB)}$ is greater than or equal to 2, then $PF_{GAC} = PF_{GAC(SUB)}-1$

(10) Since $PF_{GAC(SUB)}$ is less than 2, then: $PF_{GAC} = PF_{GAC(SUB)}/2$
$$= 1.9529/2 = 0.9764$$

(c) Payment Factor for Voids

Since lot mean VMA is less than or equal to 0.5% below minimum VMA, then:

$$PF_{VMA} = 1.000,$$

Otherwise use Formulae (11) or (12) in 313 i.e.:

(11) If $(VMA_{min} - VMA_{mean}) \geq 2.5$, then $PF_{VMA} = 0$

(12) IF $(VMA_{min} - VMA_{mean}) < 2.5$, then:

$PF_{VMA} = 0.8000-0.4(VMA_{min} - 0.5 - VMA_{mean})$

(d) Comparing the Payment Factors of Air Voids and VMA

***For Superpave mixes*:**

Since PF_{VMA} is equal to 1.000:

$PF_{VOIDS} = PF_{AIR\ VOIDS} = 1.0200$

However, if PF_{VMA} is less than 1.000, PF_{VOIDS} is the lesser of $PF_{AIR\ VOIDS}$ and PF_{VMA}

***For SMA mixes*:**

$PF_{VOIDS} = PF_{GAC}$, if $PF_{GAC} < 1$, or $PF_{VOIDS} = 1.000$, if $PF_{GAC} \geq 1.000$

(e) Combined Mix Properties

From **Formula (13) in 313**, Calculate $PF_{M(SUB)}$:

(13) $PF_{M(SUB)} = PF_{GAC} + PF_{VOIDS}$

$= 0.9764 + 1.0200 = 1.9964$

Calculate $PF_{GAC/VOIDS}$ from Formulae (14) or (15) in 313:

(14) If $PF_{M(SUB)}$ is greater than or equal to 2, then:

$PF_M = PF_{M(SUB)} - 1$

(15) However, since $PF_{M(SUB)}$ is less than 2, then:

$PF_M = PF_{M(SUB)}/2$

$= 1.9964/2 = 0.9982$

(f) Combined Mix Properties and Compaction

Calculate $PF_{MC(SUB)}$ Using Formula (16) in 313

(16) $PF_{MC(SUB)} = PF_C + PF_M$

$= 1.0240 + 0.9982 = 2.0222$

Calculate PF_{MCL} from Formulae (17) or (18) in 313:

(17) Since $PF_{MC(SUB)}$ is greater than or equal to 2 then:
$PF_{MC} = PF_{MC(SUB)} - 1$

$= 2.0222 - 1.0000 = 1.0222$

Otherwise:

(18) However, if $PF_{MC(SUB)}$ is less than 2 then:
$PF_{MC} = PF_{MC(SUB)} /2$

PFMC has to be reported to four decimal places in accordance with Appendix B.

Chapter Three

STATISTICAL COMPARISON OF QUALITY CONTROL VERSUS QUALITY ASSURANCE TESTING

3-1 General

This chapter has been prepared for contracts **with** an end result specification for the acceptance of hot mix **based on** aggregate gradation, asphalt cement content, air voids, VMA and compaction. This chapter will assist the Contract Administrator in comparing the Contractor's QC test results with the Owner's QA results, in order to assess the conformance of hot mix to the contract specifications for the required attributes.

A statistical comparison of the Contractor's QC and the Owner's QA test results for each attribute is performed **in order** to determine whether the two sets of test data are deemed to be in agreement. Examples of this comparison and a description of the computer program designed to make this comparison are described in this chapter.

The following changes have been made to the program this year:

- **The Tender Opening Date Reduction Factor has been eliminated (it's now 1.0 for all mixes).**
- **The use of QA test results for mix acceptance/PF calculations has been enabled.**
- **The formulas in the Sublot Data Input table on the "FIN" page to the "FIN" page in cells I8 to I11 have been changed.**
- **The option selections on the "FIN" page in cells I8 to I11 have been modified.**
- **One input cell, I10, has been added on the QC page, for JMFs with downward %AC adjustment to allow re-setting of the LL for a revised JMF.**
- **The number of flags signalling QC/QA data disagreement on the "QCvQA" page has been reduced from the original 11 to 4 (four) as listed in subsection 3-3.2 with the rest being left to the user's judgement.**
- **A range of cells has been added on "AddData" page for input of sublot sampling/sample location. The data entry format is being left up to the user.**

3-2 Sampling for QC / QA

For each QC sample that the Contractor takes, the Contractor must also take additional (replicate) samples for the Owner's QA testing and for referee testing (See Chapters 1 and 2).

Loose Hot Mix:	Three samples, from 20 to **45** kg for SMA or Superpave at each sample location are taken from the same truckload and at the same transverse offset.
Cores:	Three cores, at a spacing of 1.0 ± **0.1** metres between one another are taken at the same transverse offset.

3-3 Hot Mix ERS Payment and QC/QA Comparison Microsoft® Excel Spreadsheet

In order to automate the calculations for QC/QA comparison, the Bituminous Section has developed a Microsoft® Excel spreadsheet computer program to compare QC and QA results, for lots with 3 or more sublots. The following tab names are used to navigate among the various worksheets:

TAB NAME	SHEET
Guide	**Basic User Information**
QC	QC LOT PAY FACTOR CALCULATION Sheet,
QA	QA LOT PAY FACTOR CALCULATION Sheet,
QCvQA	LOT PAY FACTOR COMPARISON (QC vs. QA) Sheet,
REF	Referee LOT PAY FACTOR CALCULATION Sheet,
AddData	Additional Attributes/Requirements Record Sheet
OutC	TEST FOR OUTLIER Calculation Sheet
FIN	FINAL Composite Pay Factor Calculation Sheet,
App	Appendix (supporting statistical tables etc.)

To *Move* within any individual worksheet, you can use the scroll bars shown or the arrow keys (←↑→↓). The PgDn, PgUp, Alt+PgDn, Alt+PgUp, may also be used to move one screen down, up, to the right or to the left.

To *Print* the currently displayed page, the user may click on the 'Print' button located at the top left 'or highlight the area to print and simply print using the print selection process.

DATA INPUT:

The workbook and all individual sheets are password protected so that the formulae cannot be accidentally altered or erased. Areas where data are to be input are unprotected and shaded green or yellow for better clarity. Although the cells are fully editable (including the format), the format of the cells should not be edited or changed by the user. For partial QA, the data is simply entered in the appropriate numbered sublot row on the QA sheet.

The following number of significant digits should be used for data entry and rounded in accordance with LS-100 (i.e. Appendix B):

To the Nearest Whole Number:	Thickness, Stability
To One Decimal Place:	Individual (% passing) gradation results, Individual percent compaction values, Air void values, Lower and upper limits, VCA_{drc}, VCA_{mix} (for SMA), VFA, Dust Proportion, Flow, G_{mm} at N_{ini} and N_{max}, Tensile Strength Ratio (for SMA and Superpave)

To Two Decimal Places:	Asphalt cement content, Lower and upper quality indices, VMA, Draindown
To Three Decimal Places:	Core MRD, Plate MRD

If any technical difficulties are encountered with the program, please contact:

Ministry of Transportation,
Bituminous Section,
Materials Engineering and Research Office,
Room 238, Building "C",
1201 Wilson Avenue,
Downsview, Ontario, M3M 1J8

Telephone: (416) 235-3715

It is strongly recommended that the lot data file name be established (i.e. rename the file with the mix type and lot number as detailed in Section 3-3.3 before entering data) and that all input data be frequently saved.

The rest of this section includes general instructions for the use of the Microsoft® Excel Program, depending upon whether **acceptance is based on the Owner's QA or the Contractor's QC test results.**

3-3.1 Owner Testing for Acceptance (i.e. OPSS 313, modified by SP 103S35)

1. 'QC' Sheet: The general contract information should be input into the top of the 'QC' sheet as described in Section 3-3.2. This information will be automatically repeated on the 'QA', 'QCvQA', 'REF' and 'FIN' sheets.
2. 'QA' Sheet: The QA test data is input into the 'QA' sheet. The test data for each sublot should be input into cells B14 to I25 of the 'QA' sheet, for the Designated Large Sieve, 4.75mm sieve, 600 micron sieve, 75 micron sieve, Asphalt Cement Content, Air Voids, VMA and Compaction. The rest of the 'QA' sheet displays lot calculation results and calculates the intermediate and final pay factors. The final calculations shown are for the Total Pay Factor (PFtotal). The number of sublots and date tested should also be input into this sheet.
3. If Referee testing is invoked, then the referee results should be inserted into the 'REF' sheet described in Section 3-3.2.
4. The instructions for using the final composite pay factor (i.e. 'FIN') sheet and the recommended conventions for saving and naming of files are given in Sections 3.3-2 and 3-3.3, respectively.
5. To determine if a sublot result within a lot is an outlier, a statistical test is available in the 'OutC' sheet described in Section 3-3.2.

3-3.2 Contractor Testing with QC results used for Acceptance (i.e. OPSS 313 – Clause 313.08.01.02).

1. The 'QC', 'QA', 'QCvQA' , 'AddData' and 'FIN' sheets are used in this case. The 'REF' sheet should only be used if Referee testing has been invoked. The 'QC', 'QA', and 'REF' sheets are almost identical except they are used for QC, QA, and Referee results, respectively.

   The 'QC' sheet is used to enter the general contract information and QC test results. The general contract information is input at the top of the sheet and will automatically be repeated on the 'QA', 'QCvQA', 'REF' and 'FIN' sheets. The Region, Mix type and layer can be selected from drop-down menus. To the right of "MIX TYPE", one of the following recommended codes should be used (or click on cell B8, and choose the mix type from the drop down menu):

Mix Type	Recommended Code	
Superpave 37.5	SUP375	
Superpave 25.0	SUP250	
Superpave 19.0	SUP190	
Superpave12.5FC 2	SUP125FC2	
Superpave12.5FC 1	SUP125FC1	
Superpave12.5	SUP125	
Superpave 9.5	SUP095	
SMA	SMA	
Recycled Hot Mix	RHM	
Open Friction Course	OFC ←	**This mix has now been replaced by SMA**
Medium Duty Binder Course	MDBC	
HL8	HL8	
HL4	HL4	
HL3A	HL3A	**These mixes have now been replaced by Superpave Mixes**
HL3	HL3	
HL2	HL2	
HL1 Modiifed	HL1	
HL1	HL1	

   The Job Mix Formula (JMF) designation number is placed in cell A13 and the JMF data in cells B13 to F13 and I13. The QC test data should be input into the green-shaded areas of the 'Sublot Data Input' table. The sublot test results are to be entered in cells B14 to I25, for the Designated Large Sieve, 4.75 mm sieve, 600 μm sieve, 75 μm sieve, Asphalt Cement Content, Air Voids, Compaction and VMA. In addition, the mean combined aggregate density should be entered in cell I9 **and the Job Mix Formulae's (JMF's) lower limit for %AC. If the JMF change applied to this lot and if the change resulted in a decrease in the design %AC, then select 0.3, otherwise select 0.4**. The rest of the sheet displays the lot calculation results and the intermediate and final pay factors. The Total Pay Factor (PF_{total}) represents the final calculation.

2. The 'QA' Sheet is used to enter the QA test data. The number of sublots is entered in cell D7, the date of testing in cell D9 and the combined aggregate density in cell I9. Ensure that the results for the all of the sublots are entered in their correctly numbered sublot rows (i.e. between rows 14 and 25). The rest of the sheet displays the lot calculation results and the intermediate and final pay factors. The Total Pay Factor (PF_{total}) represents the final calculation.

3. The 'QCvQA' Sheet does not require any input. It automatically uses the information from the 'QC' and 'QA' sheets for the QC/QA comparison of Pay Factors. At the bottom of the 'QC & QA Comparison' sheet (Cells F42 and F43), there will be a

comment with a suggested action for each of the mix properties and the compaction in the 'Action' column. The list of suggested actions is as follows:

"Data is in disagreement. Consider Referee for Mix Properties";
"Use QC results for **the** acceptance of Mix Properties";
"Use QC results for **the** acceptance of Compaction";
"Data is in disagreement. Consider Referee for Compaction".

It should be noted that when the cursor is positioned in cell J41, there is a note reminding the user that Referee testing of the entire lot may be invoked by either party, regardless of the difference in QC and QA payment factors.

4. The 'REF' Sheet should be used only to input Referee test results when Referee testing has been invoked. The name of the Referee lab should be entered in cell H7 and the date of referee testing in cell D9. Sublot referee results for mix attributes (gradation, AC content, air voids and VMA) and/or the results for compaction are to be entered in some or all of the cells B14 to I25, depending on which properties were referee-tested. *If the Referee is instructed in cell G9 to conduct the Combined Aggregate Density (CAD) testing, then its value should be entered in cell G11.* Comparison of QC and QA results for CAD is included **in cell H40. A note is given in cell I40**. The rest of the sheet displays lot calculation results and calculates the intermediate and final pay factors. The final calculations are for the total pay factor "PF_{total}".

5. An 'AddData' Sheet includes other contractual information such as **sampling location,** thicknesses, **BRD's etc**. The Contract requirements for layer thicknesses, core and **loose mix** MRD's and BRD's, VMA, G_{mm} at N_{ini} and G_{mm} at N_{max} are input in the appropriate cells in row 15. The QC and QA test results (and REF for draindown) are input into the appropriate cells E17 to AA28 as required. Appropriate columns are displayed for data entry when a specific mix type is selected on the "QC" page.

6. The 'OutC' Sheet is used to check any group of sublot test results for outliers. Enter the number of sublots in cell D3, the suspected result in cell D4 and the other sublot results for the specific characteristic/property in the cells below cell D4. The outcome of the statistical test will be displayed in cell H5. For comparison, answers for three different significance levels (0.5%, 1.0% and 2.5%) are provided.

7. The 'FIN' Sheet is to be used to confirm the "FINAL COMPOSITE LOT PAY FACTOR". The input that is required in this sheet is the selection of 'QC', **QA (where applicable)** or 'REF' from the drop-down boxes activated when clicking on the shaded cells **from I8 to I11 (see associated notes by moving cursor to upper right of H8, H10 and H11).** Once the options are selected for payment purposes, the program will import the appropriate data from the 'QC' and/or 'REF' sheets and calculate the final pay factor at the bottom of the page in the cell beside PF_{total}.

8. Section 3-3.3 gives the recommended conventions for saving and naming of files.

3-3.3 Conventions for Saving and Naming of Files

It is suggested that the original copy of the template be kept as a backup file and a template-based separate data file be created for each lot and saved under an appropriate unique name. A separate folder should be created for each mix type, containing the files of all lots of that mix type. Another folder should be created for each paving contract which contains all of the folders for the individual mix types.

A typical file name should consist of up to 11 characters followed by the standard ®Excel extension of xls (i.e. *SMA03.xls or SUP125FC215.xls*). The first three to nine characters (i.e. SMA or SUP125FC2) represent the mix type designated in accordance with the recommended codes given in Subsection 3-3.2 and the last two characters before the extension identify the lot number (i.e. 03 for lot three, 15 for lot 15).

The use of this convention for the naming of files will assist MTO staff when tracking results from many different contracts. ALL files/folders must be forwarded to the applicable MTO Regional Quality Assurance Office at the completion of paving on each contract.

Questions regarding the program or the inputting of data **should** be addressed **with** the **appropriate Regional Quality Assurance Officer.**

3-4 Consequences of Test Results

The Contractor's QC results and the Owner's QA results will be compared by the Contract Administrator on a lot-by-lot basis to determine if they agree. The determination of the "agreement" of both sets of results (i.e. a minimum of one QA for every two QC results) will be based on the difference between the compaction payment factor and the mix properties payment factor [which includes AC content & gradation with or without voids (i.e. where voids is the lower of the payment factors for air voids and VMA for Superpave mixes or air voids only for SMA and all other mixes)], in accordance with the following:

1) If the difference between the compaction payment factor and the mix properties payment factor, calculated using the QA and QC test results, are both less than 0.025 for all Superpave **and** SMA mixes, then the QC results shall be deemed to agree.

2) If the difference in either the compaction payment factor or the mix properties payment factor, calculated for the QA and QC test results, are equal to or more than 0.025 for all Superpave **and** SMA mixes, then the results shall be deemed to disagree.

In either case, the Contractor or the Owner will both have an opportunity to engage a third party Referee laboratory to test the samples. The results of the referee testing will be used to determine the payment factors for the acceptance of the disputed properties for the disputed lots of hot mix and will be binding on both the Owner and Contractor. The costs to do the referee testing will be as follows:

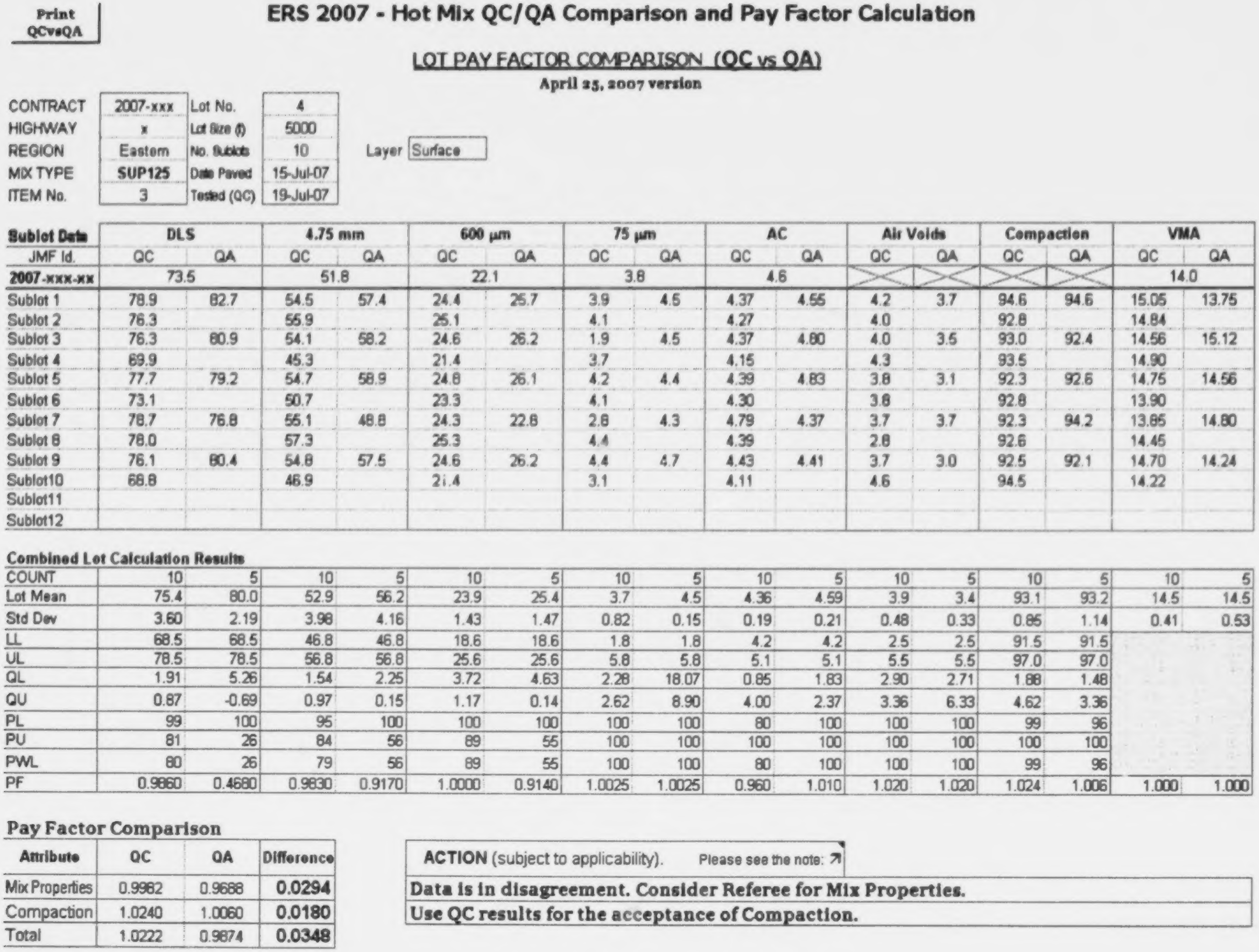
1) If the QC and QA results agree, then the cost of the referee testing will be borne by the party making the request for referee testing.

2) If the QC and QA tests don't agree, then the cost of referee testing will be borne by the party whose payment factor is further removed from that generated by the Referee laboratory.

3) If the QC and QA tests don't agree and the payment factor determined by referee testing is exactly between the payment factors from the QC and QA tests, then the cost of the Referee services must be split between the Owner and Contractor.

3-5 Example

The example shown on the following page from the Microsoft® Excel spreadsheet program shows a comparison between 5 QA and 10 QC test results. As the example shows, the difference in total pay factor between QC versus QA test results for Superpave 12.5 (i.e. 0.0348 or 3.48%) is greater than 2.5%, as shown by bolded total on last line. Therefore referee testing must be considered.



Print QCvsQA

ERS 2007 - Hot Mix QC/QA Comparison and Pay Factor Calculation

LOT PAY FACTOR COMPARISON (QC vs QA)

April 25, 2007 version

CONTRACT	2007-xxx	Lot No.	4
HIGHWAY	x	Lot Size (t)	5000
REGION	Eastern	No. Sublots	10
MIX TYPE	SUP125	Date Paved	15-Jul-07
ITEM No.	3	Tested (QC)	19-Jul-07

Layer Surface

Sublot Data	**DLS**		**4.75 mm**		**600 µm**		**75 µm**		**AC**		**Air Voids**		**Compaction**		**VMA**	
JMF Id.	QC	QA	QC	QA	QC	QA	QC	QA	QC	QA	QC	QA	QC	QA	QC	QA
2007-xxx-xx	73.5		51.8		22.1		3.8		4.6						14.0	
Sublot 1	78.9	82.7	54.5	57.4	24.4	25.7	3.9	4.5	4.37	4.55	4.2	3.7	94.6	94.6	15.05	13.75
Sublot 2	76.3		55.9		25.1		4.1		4.27		4.0		92.8		14.84	
Sublot 3	76.3	80.9	54.1	58.2	24.6	26.2	1.9	4.5	4.37	4.80	4.0	3.5	93.0	92.4	14.56	15.12
Sublot 4	69.9		45.3		21.4		3.7		4.15		4.3		93.5		14.90	
Sublot 5	77.7	79.2	54.7	58.9	24.8	26.1	4.2	4.4	4.39	4.83	3.8	3.1	92.3	92.6	14.75	14.56
Sublot 6	73.1		50.7		23.3		4.1		4.30		3.8		92.8		13.90	
Sublot 7	78.7	76.8	55.1	48.8	24.3	22.8	2.8	4.3	4.79	4.37	3.7	3.7	92.3	94.2	13.85	14.80
Sublot 8	78.0		57.3		25.3		4.4		4.39		2.8		92.6		14.45	
Sublot 9	76.1	80.4	54.8	57.5	24.6	26.2	4.4	4.7	4.43	4.41	3.7	3.0	92.5	92.1	14.70	14.24
Sublot10	68.8		46.9		21.4		3.1		4.11		4.6		94.5		14.22	
Sublot11																
Sublot12																

Combined Lot Calculation Results

COUNT	10	5	10	5	10	5	10	5	10	5	10	5	10	5	10	5
Lot Mean	75.4	80.0	52.9	56.2	23.9	25.4	3.7	4.5	4.36	4.59	3.9	3.4	93.1	93.2	14.5	14.5
Std Dev	3.60	2.19	3.98	4.16	1.43	1.47	0.82	0.15	0.19	0.21	0.48	0.33	0.85	1.14	0.41	0.53
LL	68.5	68.5	46.8	46.8	18.6	18.6	1.8	1.8	4.2	4.2	2.5	2.5	91.5	91.5		
UL	78.5	78.5	56.8	56.8	25.6	25.6	5.8	5.8	5.1	5.1	5.5	5.5	97.0	97.0		
QL	1.91	5.26	1.54	2.25	3.72	4.63	2.28	18.07	0.85	1.83	2.90	2.71	1.88	1.48		
QU	0.87	-0.69	0.97	0.15	1.17	0.14	2.62	8.90	4.00	2.37	3.36	6.33	4.62	3.36		
PL	99	100	95	100	100	100	100	100	80	100	100	100	99	96		
PU	81	26	84	56	89	55	100	100	100	100	100	100	100	100		
PWL	80	26	79	56	89	55	100	100	80	100	100	100	99	96		
PF	0.9860	0.4680	0.9830	0.9170	1.0000	0.9140	1.0025	1.0025	0.960	1.010	1.020	1.020	1.024	1.006	1.000	1.000

Pay Factor Comparison

Attribute	**QC**	**QA**	**Difference**
Mix Properties	0.9982	0.9688	**0.0294**
Compaction	1.0240	1.0060	**0.0180**
Total	1.0222	0.9874	**0.0348**

ACTION (subject to applicability). Please see the note: ↗

Data is in disagreement. Consider Referee for Mix Properties.

Use QC results for the acceptance of Compaction.

Chapter Four

PERFORMANCE-GRADED ASPHALT CEMENT (PGAC)

This chapter has been adapted from the document entitled *"1998 Guide For the Use of Performance Graded Asphalt Cement (PGAC) in MTO Contracts"*. Information regarding compaction and recompaction of mixtures containing PGAC has been modified since then.

4-1 Introduction

The Ministry of Transportation of Ontario (MTO) adopted the use of Performance Graded Asphalt Cement (PGAC) in 1997 and interim PGAC guidelines and specifications were released in May of that year. Since 1999, Ontario has been divided into three geographical zones, with appropriate PGAC upgrades for highways with heavier traffic. The MTO modifies the specified PGAC grades in each zone for mixes with more than 20% RAP. For MTO rural freeway/urban arterials and urban freeways, there is an automatic increase of one or two grades to the high temperature side.

4-2 Superpave

Superpave is the main product of the asphalt portion of the Strategic Highway Research Program (SHRP). Superpave is a system comprising the binder (asphalt cement) specification, a volumetric mix design procedure (using the Superpave Gyratory Compactor) and mix performance prediction system. Superpave is being implemented by most agencies in stages, with the adoption of binder specifications being the first phase.

In Superpave, asphalt cements are designated as PG XX-YY, where XX and YY are the summer and winter design pavement temperatures, in °C, a range within which the asphalt cement is expected to perform. Grades are in 6 degree increments. The design high and low performance temperatures are related in part to the climatic conditions for the locale, the traffic loading anticipated on the pavement structure and the position of the hot mix layer within the pavement structure. The presence and percentage of RAP also impacts on the appropriate PGAC grade. With pavement temperatures, the concept of reliability must also be appreciated, i.e. the probability that a given range limit may be exceeded.

Numerous publications provide in-depth treatment of Superpave and related specifications. For example, the Asphalt Institute publication entitled *"Superpave- Performance Graded Asphalt Binder Specification and Testing"*, Superpave Series No. 1 (SP-1) is an excellent source of information.

4-3 Geographical Zones for PGAC

For PGAC use, Ontario has been divided into the following three zones:

Zone 1: is the area north of the boundary formed by the French River, Lake Nipissing, and the Mattawa River (unchanged from 1997).

Zone 2: is the area south of Zone 1, and north of a line from Honey Harbour, to Longford, Taylor Corners, Cavan, Cambellford, and Mallorytown.

Zone 3: is the area south of Zone 2.

The zones are illustrated in Figure 4-1. They are delineated on the basis of temperature contours at a 98% reliability level from available weather data and with due regard to the relationship between pavement and air temperatures, as established by the Long Term Pavement Performance (LTPP) studies. Where available, the major towns closest to the temperature contours are selected as the boundary between zones. Some generalisation of the zone mapping is necessary, in order to avoid the creation of mini-zones due to localised variations in climatic data.

For design purposes:

- Towns located along a zone boundary line are to be included in the zone south of the boundary line.
- Projects located within 10 km of the zone boundary lines may be included in either zone, at the discretion of the designer, so that they may be considered as being within a single zone.

4-3.1 Zones for MTO Administration

The Ontario-wide zones can be modified for MTO purposes using the flexibility allowed in the previous section and any other administrative criteria at the discretion of the applicable Regional Geotechnical Section. For example:

- the Regional boundary between Owen Sound and Huntsville can be used as the northern boundary between Zones 2 and 3.
- the Regional boundary between Bancroft and Central Region (approximately the Huntsville District boundary to Highway 7) can be used by Central Region as a Zone 3 boundary.

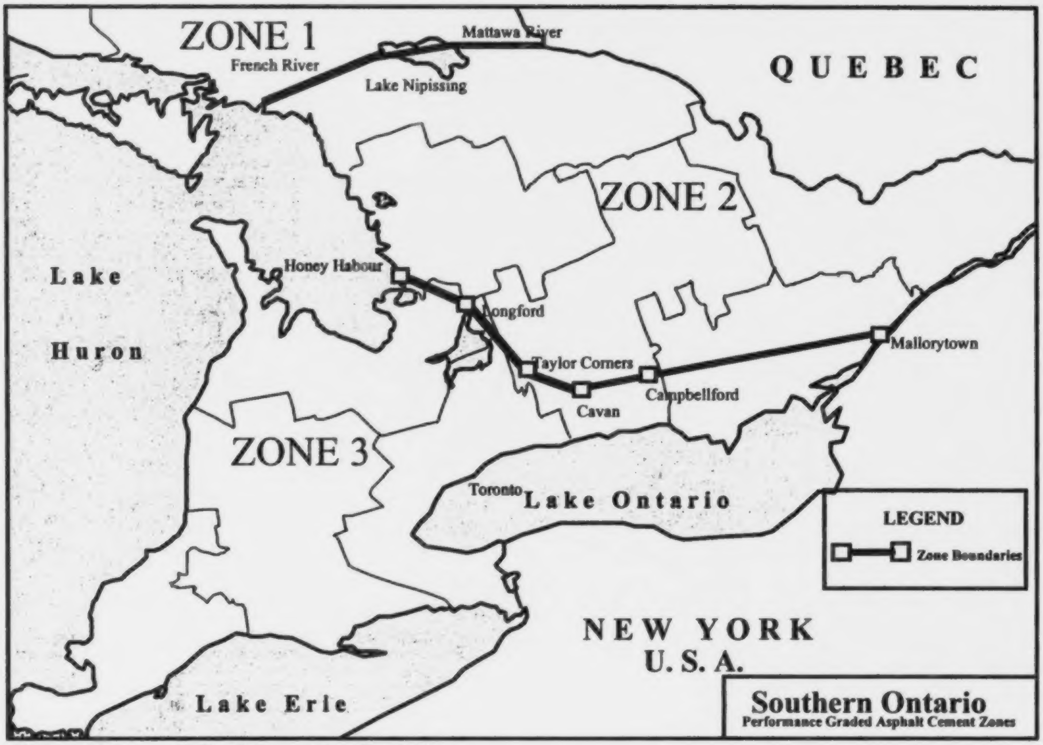

ZONE 1
French River
Mattawa River
Lake Nipissing
QUEBEC
ZONE 2
Lake Huron
Honey Habour
Longford
Taylor Corners
Campbellford
Cavan
Mallorytown
ZONE 3
Toronto
Lake Ontario
LEGEND
Zone Boundaries
NEW YORK
U.S.A.
Lake Erie
Southern Ontario
Performance Graded Asphalt Cement Zones

Figure 4-1: PGAC Zones for Ontario

4-4 Grade Selection For MTO Contracts

Performance graded asphalt cements are selected on the basis of:

- the location of the contract, i.e. the geographical zone in which it is located, noting that some discretion is allowed;
- the type of hot mix (new versus recycled hot mix); and
- upgrades for highways with heavier traffic as appropriate.

Table 4-1 provides the basic performance grades for each zone in MTO contracts. Two basic PGAC grades are specified for each zone, one for new hot mix or mix containing up to 20 percent recycled asphalt pavement (i.e. RAP), and the other for mixes containing 21 to 40 percent RAP. Since 1998, for recycled mixes containing up to 40 percent RAP, the required PGAC is specified for each zone, (i.e. a design based on recovered penetration is not required). Recycling ratios in excess of 40 percent should be addressed on a contract specific basis, in consultation with the appropriate Regional and Head Office units.

It should be noted that PG 52-40 is not widely used in large quantities. As such, the price and availability of this product may result in "value engineering" type proposals from contractors wishing to substitute PG 52-34 for PG 52-40 during construction, especially for recycled mixes. Such proposals should be discussed with the applicable Regional and Head Office units.

Table 4-1: Grade Selection for MTO Contracts

	PGAC		
	Zone 1	Zone 2	Zone 3
New Hot Mix Or up to 20% RAP	52-34	58-34	58-28
21% to 40% RAP	52-40	52-40	52-34

4-4.1 Upgrades for Heavy Traffic

Superpave specifications recommend upgrades of the high temperature performance grade when the pavement is expected to experience heavy traffic loading. For Ontario use, Superpave guidelines have been interpreted in terms of highway classification and/or commercial truck traffic. The guidelines are presented in Table 4-2. It is recommended that the applicable Regional Geotechnical office be consulted for the application of these guidelines.

As shown in Table 4-2, for MTO rural freeway/urban arterials and urban freeways, there will be an automatic increase of one or two grades to the high temperature side, respectively which will provide an additional margin of safety against premature rutting.

4-5 Supply of PGAC

The MTO has created a separate listing in the Designated Sources for Materials (DSM) for PGAC.

4-6 Determination of the Laboratory Mixing and Compaction Temperatures of Hot Mix for Design of Pavement Mixtures

The viscosity-temperature relationship of an asphalt cement is used as a guide for establishing the mixing and compaction temperature in the laboratory. The temperature to which the asphalt cement must be heated in order to produce a viscosity of 0.17 ± 0.02 Pa.s is the mixing temperature. The temperature to which the asphalt cement must be heated to produce a viscosity of 0.28 ± 0.03 Pa.s is the compaction temperature. This has been the guide for Marshall mix design criteria and the relationship continues to be valid for laboratory purposes within Superpave. In Ontario, the mixing and compaction temperatures are the temperatures where the asphalt cement has a viscosity of 0.17 and 0.28 Pa.s respectively.

The Brookfield Viscometer is a rotational device (ASTM D 4402) which is used to determine the mixing, compaction and pumping temperatures in the Superpave system. Viscosity measurements at 135° C and 165° C are plotted on a log viscosity vs. temperature chart which is used to interpolate the mixing and compaction temperatures.

The procedure for establishing the mixing and compaction temperatures from the laboratory is valid for refinery-produced asphalt cements but may not be valid for some polymer-modified asphalt cements. The supplier of these asphalt cements must be consulted for their recommendations regarding the mixing and compaction temperatures.

The relationship between temperature and viscosity given in Figure 4-2 shows the idealised laboratory mixing and compaction ranges. The asphalt cement acts as a "super lubricant" within the mixing temperature range and a "super glue" within the compaction temperature range.

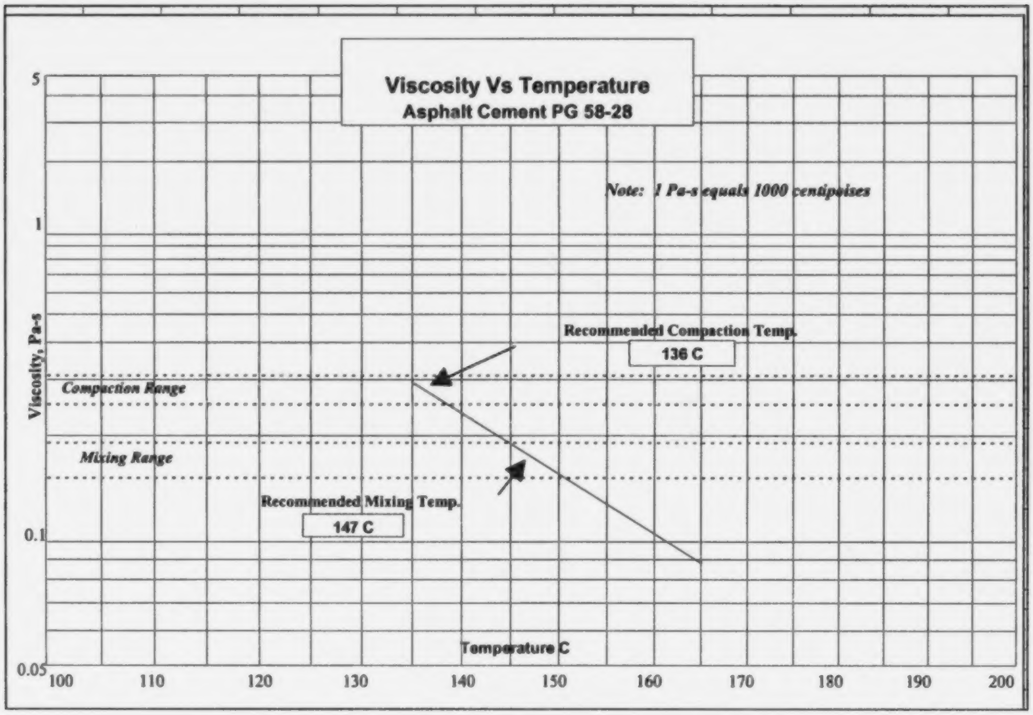
Table 4-2: Guidelines for the Modification of PGAC High Temperature Grade Based on Highway Classification and Traffic Conditions

Roadway Classification		Changes in PGAC Grade	
		Increase From Standard Grade	**Optional Additional Increase in Grade**
MTO Highways	Urban Freeway	2 grades	N/A
	Rural Freeway Urban Arterial	1 Grade	1 Grade
	Rural Arterial Urban Collector	Consider increasing by 1 grade if heavy truck traffic > 20%	1 Grade
	Rural Collector	No Change	1 or 2 grades
	Rural Local		
	Urban / Suburban Local		
Municipal Roadways	Upper Tier - Expressway Type - Arterial Large Lower Tier Arterial	1 grade	
	Large Lower Tier - collector - rural - local urban - local suburban Small Lower Tier - all categories	No Change	

Notes: 1) Upgrading of the high temperature grade is recommended for use in both surface and top binder courses (i.e. the top 80 mm to 100 mm of hot mix).

2) For roadways which experience a high percentage of heavy truck traffic and/or bus traffic at slow operating speeds with frequent stops/starts and/or historical concerns with instability rutting, consideration should be given to an increase in the high temperature grade.

Figure 4-2 – Viscosity Versus Temperature (PG 58-28)



4-7 Compaction Temperatures at Design and for Reheated Mix

The appropriate compaction temperatures for hot mix are important in determining the void properties of the mix at the design stage and during construction.

For new hot mix incorporating refinery-produced asphalt cement, the compaction temperature is typically obtained from a Temperature Viscosity Chart for the specific product. However, the use of temperature viscosity charts may not be valid for some polymer-modified asphalt cements and the suppliers of such products will need to specify the compaction temperature to be used with their products.

The appropriate compaction temperature for reheated mixtures has been the subject of considerable study and discussion by the Superpave Implementation Committee. It has been agreed with industry that, for all asphalt mixtures (including recycled mixes), the Contractor will now specify the compaction temperature for reheated mix. This may be the same but can never be less than the compaction temperature employed during mix design.

4-8 Compaction Temperatures of Hot Mix Containing Recycled Asphalt Pavement (RAP)

It should be noted that since RAP can include new Roof Shingle Tabs (RST), for the purposes of this section, each 1% RST added to the mix, will be considered to be equivalent to 10% RAP.

4-8.1 Compaction of Hot Mix Containing Up to 20% RAP

The direction provided in Section 4-8 for new hot mix will also be applicable for hot mix containing up to 20% RAP. This means that the compaction temperature for the reheated mix may be the same but can never be less than the compaction temperature employed in the design of these mixtures.

4-8.2 Compaction Temperatures For Mixes Which Contain 21 to 40% RAP

Such mixes incorporate a "softer" grade of PGAC which is either specified in the contract (for RHM items) or is selected by the Contractor in accordance with guidelines available elsewhere.

a) For mixes containing 21 to 30 % RAP, the compaction temperature must be 3°C higher than the compaction temperature stipulated by the proprietor of the PGAC for the product specified/used.

b) For mixes containing 31 to 40 % RAP, the compaction temperature must be 6°C higher than the compaction temperature stipulated by the proprietor of the PGAC for the product specified/used.

These proposals make a number of assumptions, including:

- that all RAP materials are similar in terms of the properties of the residual asphalt cement; and
- that all PGAC products "harden" similarly when mixed with RAP and when subjected to plant conditions.

While the assumptions given above may not be valid, it is important to adopt this uniform approach for the testing of recycled asphalt mixes.

4-8.3 Examples of Compaction Temperature Determinations

Situation A (Up to 20% RAP): Supplier X, PG 58-28

	New Hot Mix*
Mix Design Temperature	140° C
Compaction Temperature for Reheated Hot Mix Asphalt (HMA)**	≥140° C

* Supplied with mix design submission

Situation B (21 to 40% RAP): Supplier Y, PG 52-34

New hot mix specifies the use of PG 58-28, the Contractor elects to supply mix with RAP (percentage in the range of 21 to 40 %) which requires the use of PG 52-34 to be provided by Supplier Y.

	Data for PG 52-34 *	21 - 30 % RAP	31 – 40 % RAP
Mix Design Temperature	142° C	145° C	148° C
Compaction Temperature for Reheated Hot Mix Asphalt (HMA)**	≥142° C	≥145° C	≥148° C

* Supplied with mix design submission

** Specified by Contractor

Chapter Five

ACCEPTANCE OF PAVEMENT BASED ON VISUAL OBSERVATION

5-1 General

The purpose of this section is to provide guidelines for the acceptance of bituminous pavement on the basis of its surface appearance, as specified in Section 313.08.01.04.01 of OPSS 313.

Visual deficiencies, other than segregation, **are** dealt with as "Other Pavement Surface Defects", as described in Section 5-4.

Segregation, as well as all other visual deficiencies, should be dealt with as deficient workmanship, in accordance with the requirements of the Quality Control Compliance Incentive (i.e. Special Provision No. 199S53).

5-2 Visual Inspection

All Consultant Inspectors must be experienced in segregation assessment, prior to carrying out any visual inspection of the compacted hot mix. It is recommended that, at the beginning of the contract, the Contract Administrator's Inspector work closely with the applicable Quality Assurance Officer so that consistent assessments are being made throughout the Province.

The Contract Administrator must ensure that the surface texture of the mat is of uniform texture and free of segregation, fat spots [see Note 1)], flushing, oil spills, paver and roller marks and any other surface defects.

Any visually defective areas [see Note 2)] should be marked out by the Contract Administrator on the pavement surface and the marks must remain in place until the pavement has been properly assessed and repaired, if necessary. The Inspector will be required to prepare a detailed list which identifies each discrete area of defective pavement with its defect(s) and area in square metres. This may be done on the form entitled, "Visual Assessment of Hot Mix Deficiencies", which is reproduced below.

Notes 1): A "Draindown" test has been developed by AASHTO to indicate the likelihood that open-graded mixes like Stone Mastic Asphalt (i.e. SMA) will form "fat spots". Any mix which has failed the 0.3 percent requirement for the Draindown test (see Section 2-6) and has not yet developed such spots at the time construction has been completed, should be marked out in the field. Such areas should be monitored during the one-year warranty period by the appropriate Regional Quality Assurance Section and if "fat spots" develop later, then the Contractor may be required to remove and replace such material.

2) It should be noted that paver and/or roller marks may result in low-amplitude waves in the pavement which can manifest themselves as vibrations in ride (commonly known as "chatter"). If the Contract contains the smoothness specification (SP 103F31), such low-amplitude waves may not be reflected in surface smoothness measurements (i.e. a high profile index) but may be detected in ride quality. Since these waves in the

pavement can usually be detected visually, they should be treated the same as any other surface defects (see Section 6-5.3 – Effects of Chatter, Chapter 6) would be treated.

Pavement may be deemed to be defective on the basis of visual observation, at any time before the end of the construction season in which the mix was placed. Such pavement must not be paved over until a decision is made as to its disposition. However, if the Contract Administrator deems that the pavement constitutes a hazard to the travelling public, then the hazard must be immediately eliminated.

All pavement deemed defective, on the basis of visual inspection, must be brought to the Contractor's attention, in writing, as soon as it becomes evident and should be dealt with, in accordance with the requirements of the Quality Control Compliance Incentive (i.e. Special Provision No. 199S53).

VISUAL ASSESSMENT OF HOT MIX DEFICIENCIES

Region:

Contract No.:

Highway No.:

Contractor:

Inspector / Contract Admin.:

Company / MTO:

Date of Inspection:

Page: of

General Information			Visual Deficiencies						Dates (Year/Month/Day)	
Direction	Lane No.	Hot Mix Details	ocation - From/To:	Segregation		Other Deficiencies	Lane Width	Area	Date Deficient Section of Hot Mix Was Placed	Date Contractor Was Officially Notified of Deficiency (in Writing)
		Surface S), Binder (B) Padding (P) / Lift No. (First Binder Lift Placed is 1) / Hot Mix Type	(Note Stations, if Possible)	Type: Midlane (ML) Other (O)	Degree: Slight (SL, Medium (M), Severe (SEV)	(Give Details)	(m)	(m^2)		

5-3 Segregation

Segregation consists of areas with predominantly coarser texture than that of the surrounding pavement. **Segregation** is **classified as either "mid-lane segregation" or "other segregation" and it's severity is defined as either "slight segregation", "medium segregation or "severe segregation", in accordance with the definitions given in Section 313.03 of 313.**

5-3.1 Initial Notification / Corrective Action For Segregation

When the Contract Administrator first notices a segregation problem (i.e. if the Contractor has not already identified the problem and has proposed corrective action) then the Contract Administrator or his designated representative must bring the problem to the Contractor's attention verbally and then immediately follow this up in writing with a letter to the Contractor. The form letter, entitled "Sample Letter to the Contractor - #5-1", may be used. The Contractor must be instructed to take immediate preventative action, in order to preclude any reoccurrence of such segregation. The Contract Administrator must then ensure that the requirements of the Quality Control Compliance Incentive Special Provision (SP 199S53) are enforced (which may involve the assessment of a QC compliance deviation).

5-3.2 Disposition of Segregated Mix

Segregation occurring in hot mix shall be dealt with as detailed below.

1) **Slight Segregation:** Slightly segregated mix will be accepted into the work with no payment reduction.

2) **Medium Segregation:**

   a) **Binder Courses and Levelling/Padding Courses With a Total Thickness of Not Less than 40 mm [see Note 3)]**

   Medium segregation in binder, levelling and padding courses will normally be left in place with no payment reduction [see Note 4)].

   However, any areas of medium segregation that deteriorate prior to being overlaid by another pavement course must be repaired at no cost to the Ministry.

   b) **Surface Courses**

   Medium segregation in surface courses will normally be left in place with no payment reduction, or repaired at the discretion of the Contract Administrator.

3) **Severe Segregation:** All severely segregated mix must be repaired by removal and replacement.

Notes: 3) Textural problems in levelling/padding courses with thicknesses less than a normal lift of hot mix (i.e. less than 40 mm, in most cases), any bullnose or tapers that were not machine-laid and any areas of "handwork" will be dealt with solely on the basis of their workmanship and not on segregation assessment.

4) When a binder course with medium segregation will be open to traffic over the winter, the Contractor should be notified that the cost of any emergency repairs during the winter will be charged to the Contractor.

5-3.3 Continuing Segregation

When the Contractor has continuing problems with medium or severe segregation and the Contractor has not adequately dealt with (i.e. in accordance with the requirements of SP 199S53), then the matter should be brought to the attention of the Contract Control Officer and/or Area Construction Engineer. The Ministry may consider the possibility that factors beyond the Contractor's control such as experimental equipment or mix may be contributing to the problem. The Ministry will then determine whether or not to instruct the Contractor to stop paving. If the Contractor is instructed to stop paving, the Owner will not be held responsible for any additional costs that the Contractor may incur as a result of the shutdown.

After instructing the Contractor to stop but before paving restarts, a special meeting should be held with the Contractor to emphasise the seriousness of the matter and the potential for further stoppages regardless of the Contractor's proposals to make repairs and/or agreement to payment reductions and/or the issuance of QC compliance deviations. The intent of the meeting is to prevent further placement of new pavement that will not perform as well as pavement placed without segregation. The meeting should be attended by the next level of management higher than the on-site supervisors for both the Ministry and the Contractor, wherever possible. In some cases, these individuals should observe the pavement after restarting operations for themselves.

5-3.4 Challenging the Degree of Severity

A mechanism **for resolving challenges** arising from differences in the assessment of the degree of severity **is described in clause 313.08.01.04.03 of OPSS 313.**

Note 5): At one time, a further step in the challenge procedure was also available for segregation assessment of Marshall mixes which was based on the macrotexture or so-called "sand patch" test. However, since we have now moved to Superpave and do not have similar ratios developed for those mixes, we have had to remove that portion of the challenge procedure. In order for the Bituminous Section to develop similar ratios for Superpave and SMA mixes and to allow us to be in a position to re-instate challenges based on that test, the Bituminous Section should be informed (phone #: 416-235-3715) as soon as medium or severe segregation has been identified in any Superpave or SMA mix. Macrotexture testing will then be conducted for data collection only (i.e. the results will not be used to resolve contract challenges).

SAMPLE LETTER TO CONTRACTOR - #5-1
(Version 1.0)

TO: ______________________________
(NAME OF CONTRACTOR)

CONTRACT NO.:______________ HIGHWAY NO.:______________

Re: **Notice of (General/Mid-Lane) Segregation for** ________(Hot Mix type)

Segregation has been observed in the mat on ______________________ **which shall be considered "deficienct Material or work", in accordance with clause 313.08.01.04 of OPSS 313.** The (general) area(s) where this segregation has been noted **are** as follows:

Lift No.:______ Lane No.: ______ From Station:__________to Station:__________

Lift No.:______ Lane No.: ______ From Station:__________to Station:__________

Lift No.:______ Lane No.: ______ From Station:__________to Station:__________

etc.

It should be noted that there may also be other areas of segregation than those identified above.

While a formal assessment and the disposition of this mix will be determined at a later date, the Contractor is hereby informed that action is immediately required to eliminate any further incidences of segregation.

______________________________ ______________________________
Contract Administrator, MTO Date

______________________________ ______________________________
Contractor's Representative Date

cc: Head, Regional Quality Assurance

5-4 Other Pavement Surface Defects

For causes other than segregation (i.e. "other pavement surface defects"), if the Contractor has not adequately dealt with defective pavement, in accordance with the requirements of SP 199S53 , **then** the Contract Administrator should:

- Review the defective pavement, determine the quantity of hot mix involved, the severity of the problem, the disposition of the area in question and the responsibility for the cost for any remedial work, if required.
- Discuss his/her findings and recommendations with the applicable Regional Quality Assurance Section (and possibly the Bituminous Section) prior to informing the Contractor.
- Enforce the requirements of SP 199S53 up to and including the issuing of deviation(s).

5-5 Repairs

The method(s) of repair chosen by the Contractor will be subject to the approval of the Contract Administrator, after first consulting with the applicable Regional Quality Assurance Section.

Generally, repairs will either consist of removal and replacement with new hot mix or a hot mix overlay, where it is permitted.

For some defects, overlays on traffic lanes beneath structures may be allowed on open roadways or beneath structures, if clearances between the pavement surface and the underside of the structure after overlay do not exceed the tolerable limit. Overlays on traffic lanes beneath posted structures, adjacent to curb-and-gutter or on bridge decks will not be permitted.

Repairs by removal and replacement or a hot mix overlay must be full lane or shoulder width (i.e. between existing longitudinal joints including any lane markings which may be present) and completed using a paver.

Localised repairs may be permissible for mid-lane segregation in binder courses, where defects other than segregation are located on a paved shoulder or where the defect is so small that it can be removed with a single core. However, it should be noted that localised repairs will not be permitted for longitudinal streaks located anywhere within the vicinity of the wheelpaths.

Where localised repairs are allowed for mid-lane segregation, these repairs must:

- Not exceed 300 mm in width
- Be to the full depth of the subject lift; and
- Be entirely tack-coated.

When a defect is located on a paved shoulder, the Contract Administrator may allow an isolated repair of the paved shoulder only.

In some cases, where the defect has a maximum dimension of 150 mm, the Contract Administrator may allow it to be removed by a single core. Where removal by core is allowed, the replacement of the pavement must be consistent with the repairs required for cored holes taken for sampling purposes. The Contractor must clean out and sponge dry the cored hole. The hole is then filled with hot mix and compacted using a mechanical compactor with a round foot slightly smaller than the diameter of the cored hole. The holes are then filled to conform with the adjoining undisturbed pavement.

Hot mix used in all repairs must meet the requirements specified for the tender item in the Contract. All repairs must be done in a sightly and workmanlike manner complying with all requirements for placing hot mix stated in the Contract. All repaired areas must be entirely tack-coated and all transverse joints in surface course repairs must butt up to the vertical face.

5-6 Payment Issues

5-6.1 Repairs

All repairs for remedial work due to segregated or otherwise visually-defective mix, including pavement which has been removed and replaced, additional shouldering, traffic control and any other work which has to be redone such as zone painting or bridge deck waterproofing will be made entirely at the Contractor's expense.

The Contractor will not be charged for any reclaimed asphalt pavement (RAP) used in the repairs. However, should a shortfall in RAP quantity occur on the Contract, the additional RAP used in the remedial work will be taken into consideration, in addressing the shortfall.

5-6.2 Bonuses/Price Adjustments

Some surface courses will be entitled to a bonus or, in some cases, assessed a price reduction. These conditions, along with the method used to calculate the bonus**es and price reductions are** described in **Clause 313.10.01.04** of 313.

5-7 Construction Office (St. Catharines) Involvement

It will only be necessary to refer cases to the Construction Office (St. Catharines) when, in the opinion of either the Bituminous Section or the Region, they are not fully covered herein and/or there are reasons why some variation of the policy should be applied.

Chapter
Six

MEASUREMENT AND ACCEPTANCE OF PAVEMENT BASED ON SMOOTHNESS

6-1 General

The purpose of this section is to provide guidelines for the acceptance of bituminous pavement on the basis of its surface smoothness, measured using both a profile measuring device and a straight edge.

Special Provision No. 103F31, entitled "Asphaltic Concrete Surface Tolerance and Payment Adjustment for Surface Smoothness", which will henceforth be referred to as the "SP" in the remainder of this Chapter is being applied in nearly all new contracts which involve the construction of at least one lift of hot mix.

6-2 Definitions

Any terms that are mentioned in this Chapter that the reader is unfamilar with can be found in Section 313.03 of 313, as modified by SP 103F31.

6-3 Tolerances and Surface Smoothness

6-3.1 Tolerances Measured by Straight Edge:

The requirements for tolerances apply to all hot mix, regardless of whether or not surface smoothness measurements using a profile measuring device also apply [see Note 1), below]. The requirements for tolerances are included in SP. When required, the tolerances must be measured using a rigid metal straight edge, 3 m in length, which has been approved by the Contract Administrator.

For all binder courses and their joints and all padding, the tolerances of the pavement surface must be such that when tested with a 3 m long straight edge placed anywhere, including the edge of the pavement, in any direction on the surface, except across the crown or drainage gutters, there must not be a gap greater than 6 mm between the bottom of the straightedge and the surface of the pavement.

For all surface courses, the tolerances of the pavement surface must be such that when tested with a 3 m straight edge placed anywhere including the edge of the pavement, in any direction on the surface, except across the crown or drainage gutters, there must not be a gap greater than 3 mm between the bottom of the straightedge and the surface of the pavement.

Tolerance measurements should be carried out by the Contractor for quality control. In addition, at any time, the Contractor may be required to take additional tolerance measurements at the direction of and in the presence of the Contract Administrator. In some instances, Ministry representatives may take the measurements as well [see Note 1), below].

Note: 1) Where sublots have been measured by profilograph, tolerance measurements using a 3 m straight edge can be used to check longitudinal joints and the transverse profile across a lane. The straight edge may also be used to confirm the locations of transverse bumps (scallops) shown on the traces, but it should not be used to replace profilograph results if the amplitudes of the bumps (scallops) shown on the profile traces indicate them to be acceptable, but the straight edge indicates a failure (unless the area being measured is exempt from surface smoothness-related payment adjustments and repairs). Since the baseline of a profilograph is not the same as a 3 m straight edge, different results should be expected. Therefore, if a question arises regarding the reliability of the profile traces, then the Contract Administrator can, at any time, ask the Contractor to re-run any area in the Contract Administrator's presence or hire another profilograph to do audit testing.

6-3.2 Surface Smoothness

For contracts which contain SP 103F31, where the posted speed limit is greater than 60 km/hr and the pavement consists of at least one lift of hot mix (excluding padding or levelling) consisting of at least 5000 tonnes, all surface courses must be measured for surface smoothness using the profilometer described in the special provision and in Section 6-4, except in the situations outlined in clause 313.**07.16.04** of OPSS 313 **[See Note 2)]**.

Note: **2) It should be noted that the new OPSS 313 now includes a significantly reduced list of areas that are exempt from measurements. Although this list has been reduced, any areas that were included in previous exemption lists may be included as fill-ins, if it is deemed appropriate to do so by the applicable Region.**

6-4 Profile Measuring Device (PMD) & Approval of Paving Control Technicians/Operators

6-4.1 Profile Measuring Device / Calibration and Correlation

Where surface smoothness is being measured, the Contractor must provide a computerized California profilograph or another equivalent Profile Measuring Device (PMD). Such a device has to be approved by the Ministry to measure the surface smoothness of the pavement and all scallops. For the purposes of this Field Guide, any PMD provided by the Contractor for surface smoothness measurements will be referred to as the "Contractor's PMD", regardless of who owns and/or operates it.

California profilographs must conform to ASTM E 1274–88, "Standard Test Method for Measuring Pavement Smoothness Using a Profilograph". The details of what is considered acceptable are included in LS 293.

The calibration of the Contractor's PMD must be verified for both height and distance recording. The accuracy of the height recording must be ±0.5 mm and the accuracy of the distance recording must be ± 0.3 m in 30 m at all times.

The height calibration must be checked on a daily basis, and the distance calibration checked on a monthly basis. Both calibrations must be carried out in accordance with LS 293.

In addition, the vertical calibration of the Contractor's PMD must be verified each time the PMD is re-assembled or whenever the Contract Administrator requires it.

The Contractor must also ensure that, at all times during testing, the air pressure of the measuring wheel is within the equipment manufacturer's allowance.

The Contract Administrator should occasionally check and record the air pressure of the profilograph's measuring wheel [25 p.s.i. ± 1 p.s.i. (or 170 kPa)]. He should also occasionally be present when the Operator is verifying the height and distance calibrations of his profilograph. In addition, if the Contract Administrator feels the measurements taken by the Contractor do not accurately reflect the perceived roughness of the pavement, he or she can ask the Operator to verify the height or distance calibrations in the Contract Administrator's presence at any time.

The Contractor's PMD must be correlated on an annual basis and prior to use on any of the Ministry's contracts, in accordance with LS 293.

In the past, all PMD's were only pushed manually during the correlation. However now most companies are adapting motors behind the PMD or using small garden tractors or similar vehicles to power them. For this reason, each PMD is now being approved for the mode of operation (i.e. manually or powered) which the operator is most likely to use. In addition, after each correlation, the Ministry has been engraving the rim of each approved measuring wheel, with an identification letter (and usually a signature e.g. "John A. Blair" **or "M. Ahmed"**). Therefore, before any measurements are taken, the Contract Administrator must check with the appropriate Regional Quality Assurance Office to determine the mode of operation and the measuring wheel(s) that the Contractor used during the yearly correlation. Any change in the mode of operation or repairs to any portion of the PMD or any change in the measuring wheel(s) that was (were) approved will require re-correlation at the Correlation Site. However, if the PMD was approved for powered operation, but the powering unit fails and the Contractor is forced to use it manually, then the PMD does not have to be re-correlated, as long as the powering unit is repaired and powered operation is restored within one month's time.

6-4.2 Approval of Paving Control Technicians / Operators

The Ministry requires that all companies operating profilographs must have at least one different person approved by the Ministry to supervise each profilograph that the company owns. The Ministry can approve both Operators and/or Quality Control Technicians (QCT's) or equivalents to provide direct supervision during the operation of each profilograph. In any case, regardless of who has been approved, the Ministry wants to ensure that there is at least one approved person at the site from the company that owns or operates the profilograph, while it is being run.

Every approved person must be familiar with **the smoothness-related clauses in OPSS 313,** the most current **SP**, Field Guide, LS 101, LS 293 and ASTM E1274-88 and be experienced using the equipment and interpreting the data. As a result, a written test as well as a hands-on demonstration is required for all candidates. Each successful candidate receives a signed card which must be carried when taking profilograph measurements. The Contract Administrator may ask to see that card at any time.

6-5 Surface Smoothness Measurements

6-5.1 Lot and Sublot Size

For surface smoothness measurements, a lot is defined as all pavement in a given surface course contract item that has been measured by PMD. Each lot will generally be divided into 100 m sublots, upon which corrective work and individual pay adjustments for surface smoothness will be evaluated.

Prior to the pre-pave meeting, the Contractor must present a sketch of the proposed locations for each sublot to the Contract Administrator, in accordance with the guidelines presented in this Section. The sketch should show each lane with all of it's sublots, any areas that will be excluded from being measured by the PMD, any other areas that are to be measured for information purposes (i.e. will not have surface smoothness-related payment reductions or repairs) and any areas which will be exempt from smoothness-related payment reductions only. It is not required that the sketch be drawn to scale. The stations covered by each sublot should be readily apparent from the sketch.

Each sublot will be assumed to be 100 m long, unless it is otherwise indicated on the sketch. In order to maintain 100 m sublots on steep grades or superelevations with even stations, the stations of the sublots may have to be slightly adjusted, in order to compensate for the actual measurements taken along the profile [see Note 3)]. Slightly shorter or longer sublots may be designed at the end of the steep grade or superelevation, in order to go back to even stations for any sublots that follow.

It is recommended that, for each traffic lane, all included sublots should be numbered sequentially in the direction of traffic, *no sublot should have the same sublot number as any other one* (unless one of them is from a pavement surface beneath the other) and no sublot should be carried over from one lane to the next. If only one direction is involved, then the numbering should be in the chainage direction, if at all possible. A sublot should not be broken by any area that will not be measured. Therefore, if there is an area such as a bridge in which payment reductions may apply to part of it (such as the bridge deck itself) but there are other parts where they may not apply (such as in the abutment areas), three or more sublots may be necessary to completely define the bridge (see Section 6-5.1.3).

The Contract Administrator will evaluate the validity of all of the areas which the Contractor has shown on the sketch which are not to be measured or which are claimed to be exempt from surface smoothness-related payment reductions or repairs.

There may also be some other areas where the Contractor claims he cannot sufficiently control truck traffic before the hot mix is likely to sufficiently cool, areas over rigid structures where the design profile over such structures may not permit the correction of pavement distortions or any other areas where the Contractor believes that circumstances beyond his control may prevent him from obtaining acceptable smoothness (see Section 6-5.1.4). After discussion with the appropriate Regional Quality Assurance Section and the Bituminous Section, the Contract Administrator may or may not decide to modify the Contractor's sketch. In any case, once these "Excluded Areas" have been accepted by the Contract Administrator, they will not be payment-adjusted, even if they receive a bonus and such areas will not be included in the tonnage calculation for the lot.

The Contract Administrator should mark an "X" through each accepted sublot on his or her copy of the sketch, to show that it has been completed and accepted.

The Contractor must fill out all of the applicable information in a form similar to the one shown later in this chapter. Note that the form shows that *the individual initial and final rate of smoothness measurements for both wheelpaths and their average PI's are all being placed in consecutive vertical cells*. This is critical in Excel spreadsheets so that the information can be easily transferred from file-to-file.

Note 3): It should be noted that, on grades, if the surveyed stations are horizontally-projected they will not match the actual distances travelled along the profile. Such differences should be taken into account by the Contractor when drawing the sketch, since all sublots must be 100 m along the actual measured profile (except at the end of a lane etc.). The PMD must not deviate from the stated stations by more than 1%. To avoid this, the PMD Operator should be aware that LS 293 requires that no individual profile run can be more than 500 m in length. Therefore, when each profile run has been completed, the Operator should set up at the beginning of the first sublot following the last one that was completed.

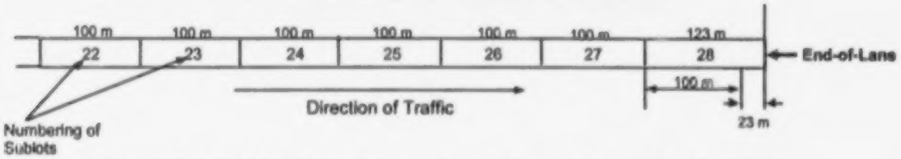
6-5.1.1 Sublots at End-of-Lane

If, after the last complete sublot within a lane, the remaining portion of the lane is greater than or equal to 50 m in length, then that remaining portion of the lane will be considered to be the last sublot in the lane and the reduction length (i.e. the input parameter which sets the sublot length) must be reduced by the Operator to the smaller sublot length. If the portion left at the end of the lane is less than 50 m in length, then it will be added to the previous sublot in the lane and the reduction length of the larger sublot must be increased by the Operator to the larger sublot length.

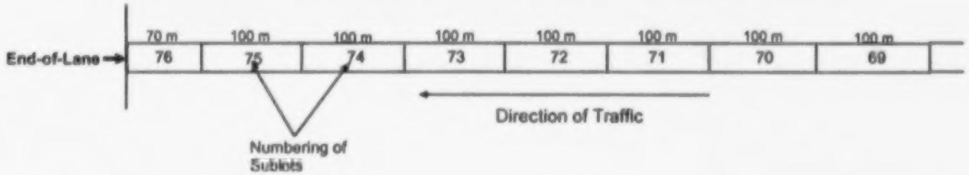
In either case, the profile index of the affected sublot will be averaged over the increased/reduced sublot length and the sublot will be considered equally with all other sublots when calculating the overall pavement factor.

Figure 6-1: End-of-Lane Sublots

Example: Sublot Less than 50 m at End-of-Lane


100 m
100 m
100 m
100 m
100 m
100 m
123 m
22
23
24
25
26
27
28
End-of-Lane
100 m
23 m
Direction of Traffic
Numbering of Sublots

Example: Sublot Equal to or More than 50 m at End-of-Lane


End-of-Lane
70 m
100 m
100 m
100 m
100 m
100 m
100 m
100 m
76
75
74
73
72
71
70
69
Direction of Traffic
Numbering of Sublots

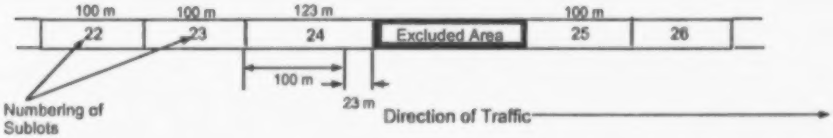
6-5.1.2 Sublots Before Excluded Areas

If an area is encountered that is excluded from smoothness measurements by profilograph, then the portion of the lane encountered prior to that area may either be added to the previous sublot or a new sublot created in the same manner as described for end-of-lane sublots in Subsection 6-5.1.1.

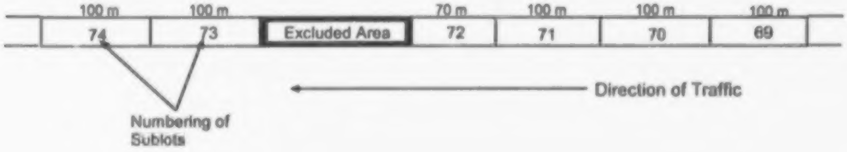
The sequential numbering of the sublots should resume after the excluded areas.

Figure 6-2: Sublots Before Excluded Areas

Example: Sublot Less than 50 m Before Excluded Area


100 m
100 m
123 m
100 m
22
23
24
Excluded Area
25
26
100 m
23 m
Direction of Traffic
Numbering of Sublots

Example: Sublot Equal to or More than 50 m Before Excluded Area

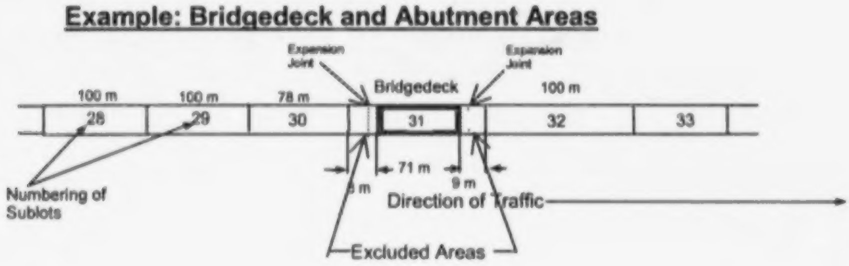

100 m
100 m
70 m
100 m
100 m
100 m
74
73
Excluded Area
72
71
70
69
Direction of Traffic
Numbering of Sublots

Where sublots have been changed in size by the Operator, the Contract Administrator must always ensure that the new reduction length has been recorded on the header accompanying the trace.

6-5.1.3 Bridge decks

The example in Figure 6-3 below, shows a bridge deck located between two expansion joints. Measurements are not required within within **10** m of the expansion joint at each end of the bridge deck. Bridge decks and bridge deck sections are excluded from measurements.

Figure 6-3: Bridge decks



6-5.1.4 Additional Excluded Areas

At the pre-pave meeting, the Contract Administrator will discuss the Contractor's sketch with the Contractor. At that time, the Contractor will be required to defend any additional areas shown on the sketch, (other than those noted in Section 6-3.2), that the Contractor believes should be excluded from measurements. Such areas may include certain intersections where the Contractor feels that the truck traffic cannot be sufficiently controlled before the hot mix has sufficiently cooled, areas over rigid structures where the design profile over such structures may not permit the correction of pavement distortions or any other areas where the Contractor expresses concern that circumstances beyond his or her control may prevent him from obtaining acceptable smoothness. The Contract Administrator will evaluate the Contractor's concerns and, after discussing with the appropriate Regional Quality Assurance Section and the Bituminous Section, the Contract Administrator may either leave the sketch the same or he may choose to modify it. In any case, any such additional areas will only be able to receive a maximum payment factor of 1.0 (i.e. no bonuses will be allowed).

The decision of the Contract Administrator regarding any additional excluded areas will be binding on both the Ministry and Contractor and the Contractor should be aware that no other areas may be excluded from the requirements for surface smoothness measurements (unless damage occurs due to circumstances beyond the Contractor's control) once paving of the surface course begins.

6-5.2 Measurement of Surface Smoothness

The Contractor must clearly mark out each sublot on the pavement surface or shoulder prior to testing. All such marks (or stakes) for the surface course must remain visible and unobtrusive until any measurements taken for payment purposes (or for the purposes of identifying scallops) are completed and accepted.

The Contractor is required to do smoothness testing within 10 business days of a sublot being constructed.

Under no circumstances whatsoever should surface smoothness measurements be taken on any asphalt that is so warm that the bogey wheels of the PMD are sinking into the mat or particles of soft hot mix are sticking to the measuring wheel.

The Contractor must give the Contract Administrator or his representative a minimum of 48 hours notice prior to the first smoothness testing carried out on each surface course item within the contract. For any other smoothness testing, the Contractor must give the Contract Administrator or his representative at least 24 hours notice prior to testing.

Initial and subsequent profile indices for a given sublot should be averaged over both wheelpaths and then rounded to the nearest whole number in accordance with the rounding procedure, LS 100, given in Appendix B.

The wheelpaths for measuring surface smoothness, are located at a distance of 1.0 m on either side of the centreline of the actual trafficked lane and these are the locations that will be measured in the event of a dispute. However, it is likely that lane painting will not be completed at the time the surface smoothness measurements are being carried out. In this case, the centreline of the lane may be approximated from the design dimensions for the lane and shoulders and suitable reference points as long as the 150 mm tolerance requirements for the wheelpath measurements will be maintained.

Where the Contractor cannot ensure that the measurements are within the required tolerances or the proposed reference line will not remain intact until the sublot has been accepted for payment by the Contract Administrator, then the Contract Administrator will have the right to require changes to the Contractor's proposed reference line or offset or, if necessary, he can require that the Contractor establish a permanent surveyed reference line for the affected sublot(s) at no additional cost to the Owner. In any case, the Contract Administrator must agree to the reference line and offset that the PMD Operator is intending to use each day.

All smoothness measurements must be done in the direction of traffic. This likely means that, after one wheelpath in a lane is measured, then the PMD must be pulled back to the beginning of the pavement section before the other wheelpath is measured.

For California-type profilographs, the testing must be carried out as per ASTM E1274-88 (LS 293 will take precedence where conflicts arise), with a blanking band height "B", set at 0 mm; i.e. a *Zero Blanking Band*.

The individual payment adjustment for a sublot can only be based on the initial profile indices, unless the sublot has either been repaired or it has been re-tested at the request of the Contract Administrator. Normally this means that the Contractor's PMD is only allowed to measure a sublot's wheelpath once.

Hot Mix - Smoothness Acceptance and Price Adjustment Sheet

☐ Daily Working Sheet

☐ Final Summary Sheet (for Payment)

Contract No.: ☐

PMD Type / Manufacturer ☐

Contractor/Owner-Operator: ☐

Highway No.: ☐

Mix Type: ☐ Page ☐ of ☐

PMD Serial No: ☐ Wheel Designation: ☐

Completed by: ☐ Date: ☐

Lane No./ Direction: ☐ Sublots ☐ to ☐

Notes: *Areas that are superelevated or on curves should be designated as "(S)" or "(C)", respectively

† If a scallop is left unrepaired, write "(U)" after its height

Sublot Information			Date	Surface Smoothness Measurements mm/km)											Sublot Payment Factor
				Contractor's Initial and Interim Measurements					Initial Measurements (For Data Transfer)			Final Measurements (For Payment)			
SubLot #	Stations* (Start / End)	Length (m)		Initial/ Subsequent Measurements		Wheelpath Left	Wheelpath Right	Mean (PI)	Wheelpath Left	Wheelpath Right	Initial PI	Wheelpath Left	Wheelpath Right	Final PI	(Based on Final PI)
				Initial											
				Sub#1											
				Sub#2											
				Sub#3											
				Initial											
				Sub#1											
				Sub#2											
				Sub#3											
				Initial											
				Sub#1											
				Sub#2											
				Sub#3											
				Initial											
				Sub#1											
				Sub#2											
				Sub#3											
				Initial											
				Sub#1											
				Sub#2											
				Sub#3											

Scallop Locations and Heights							
Initial Measurements				Final Measurements †			
Left Wheelpath		Right Wheelpath		Left Wheelpath		Right Wheelpath	
Stations	Heights (mm)	Stations	Heights (mm)	Stations	Heights (mm)	Stations	Heights (mm)

Figure 6-4: Summary Sheet For Profilograph Measurements

The Contractor must ensure that the surface to be tested is clear of any loose stones, debris etc. which could significantly affect the results. Running the PMD over such debris will not be considered as a valid excuse for re-testing a sublot.

The Contractor will always be expected to make a reasonable effort to prevent vehicles at intersections & private entrances & exits from crossing newly-placed hot mix before it has been sufficiently compacted & allowed to cool. This will involve contacting any & all affected businesses & homeowners & the placement of tapes, flagging and/or temporary barricades.

If any area has still suffered damage, due to circumstances beyond the Contractor's reasonable control, prior to being measured, then the Contractor must inform the Contract Administrator, in writing, within one working day of the damage occurring. The Contract Administrator will then decide if the area should be excluded from the requirements for surface smoothness.

The Contract Administrator must receive one continuous, unbroken, *original* profile record for all measurements conducted that same day from the Contractor. However, if the Contractor made prior arrangements to hand over the profile record to the Contract Administrator or his/her representative, yet neither were on site at the agreed-upon time, then the Contract Administrator or his/her representative must make sure that it is received the next day that one or the other is on site. The Contract Administrator should not accept either a broken daily profile record or a paper spool which has been signed on any other day except the day that the measurements were taken, for any other reason without a valid explanation from the Contractor.

It should be noted that, duplicates of profile records which are produced from electronic files on Cox Brothers profilographs sometimes neglect to include the amplitudes of one or more bumps/dips close to the ends of a sublot (thus producing a slightly reduced rate of smoothness). According to the manufacturer, such discrepancies have been known to occur only when metric units are being used and that the trace produced while the profilograph is being pushed is always the correct one. Since the Ministry has always maintained that the original trace produced at the site and handed to the Contract Administrator is the one which is used for payment purposes, it is imperative that companies operating Cox profilographs note down the profile indices for all sublots prior to handing over the daily profile record.

The daily profile record may have profile traces representing various sublots from different mix types, lifts, lanes, etc., depending on what was measured. Specific details of the notations which are required both within and on the outside of the daily profile record are included in LS 293.

Prior to doing any testing, the daily record must be signed by both the Ministry-approved PMD Operator or the Contractor's Quality Control Technician and the Contract Administrator or his representative.

When a series of sublots does not show a header with all applicable input parameters or if there is any discrepancy in the numbering of lots, stations, etc., then the Contract Administrator has the right to refuse payment for the affected sublots (i.e. they will have to be re-tested to determine the appropriate payment factors for those sublots).

Areas of special conditions, such as superelevations or curves and any additional information such as joints or major intersections should be clearly marked on the profile traces and the summary sheets.

Sublots with traces that are incomplete, of improper format, or missing shall be deemed incomplete and unacceptable for payment purposes.

After the initial profile trace is made, all areas where scallops with "S"-values greater than **14.5** mm, must be marked on the pavement surface by the Contractor prior to doing any corrective work. The Contract Administrator should review these areas prior to repair.

The *original profile traces* for pavement surfaces being measured for surface smoothness must be available to the Contract Administrator, at any time for inspection. The Contract Administrator must be given all of the *original profile traces* for all surface courses and all binder courses (when measured beneath OFC or on carry-over contracts), prior to acceptance.

The Contractor must fill out all required information for the surface course(s) and the existing or binder surface, where either has been measured, on summary forms similar to those shown in Figure 6.4. The forms must be submitted to the Contract Administrator no later than five business days following the date when the measurements were taken and prior to any corrective action taking place. Separate summary sheets shall be filled out for all of the sublots measured for payment purposes and the existing or binder surfaces where they have been measured.

The amplitudes of all scallops, shall be measured in accordance with LS 293 and recorded in the summary sheets, along with all other relevant information.

The Contractor must also provide summaries of all rate of smoothness measurements taken in both wheelpaths from each sublot in Microsoft® Excel spreadsheet file(s) on 3.5" floppy disks, CD's **or DVD's** for IBM-compatible PC's. The Excel spreadsheets should be set up so that both the individual initial and final rate of smoothness measurements for both wheelpaths and their average PI's are all being placed in consecutive vertical cells, so that the data can be easily transferred from one file to another.

The Contract Administrator must ensure that the summary sheets and all *original profile traces* are received from the Contractor, in accordance with the requirements of the specification. This will avoid conflicts which could arise later.

6-5.3 Effects of Chatter

It is possible for the driver of a vehicle to experience a vibration commonly known as "chatter" in a pavement where the profile indices indicated an acceptable ride. Experience with this phenomenon indicates that it appears to occur when a series of small amplitude regularly-spaced waves have been constructed into the pavement surface. These waves appear to have amplitudes of 0.8 to 2.0 mm and wavelengths of about 1.5 to 2.0 m, as indicated by the profile traces. Although they are numerous, the amplitudes of these waves are small enough so that they do not produce a profile index greater than the acceptable range (generally, at the upper end of the range). Such small waves would not normally be a problem, except that they are regularly-spaced and appear to set up a vibration in certain vehicles passing over them.

Since these waves appear to be caused by problems with the paver (e.g. a defective screed), the Contract Administrator should treat this phenomenon as he would with any other problem associated with a defective paver, since there is often a definite visual textural deficiency associated with it (see Section 5-2).

6-5.4 Carry-Over Contracts

For contracts containing the SP and where an upper binder course is left in place for the winter but the surface course is constructed the following construction season, the Contractor will be allowed to either:

1) Reduce the profile indices of the sublots of surface course which will be constructed over the binder course by 15 mm/km or;
2) Take surface smoothness measurements on the upper binder course both in the Fall and in the next Spring at his own cost.

Where the Contractor decides to carry out the surface smoothness measurements on the preceding (i.e. upper) binder course, then the (fall) measurements must be taken immediately prior to halting construction for the season. The Contractor will then be required to re-measure the surface smoothness of that preceding binder course in the same season that the surface course is constructed immediately after the frost has come out of the ground.

To ensure that the two sets of measurements taken on the upper binder course for payment purposes are coincident with one another, the Contract Administrator must ensure that the Contractor clearly and permanently marks the sublot stations at regular intervals of no more than 100 m and the reference lines and offsets used for each wheelpath on the pavement surface at the edge of the lane before the end of the season in which the binder is constructed.

Since such measurements are extremely important to the final payment factor for the surface course, the Contact Administrator must provide the same degree of inspection for these measurements as he is required to do for the measurements taken on the surface course.

If, in the Spring, the average profile index for all of the measured upper binder course is more than 5% greater than the measurements which were taken in the fall, then the profile index for each sublot of surface course overlying the measured upper binder course will be reduced by the difference in average profile index recorded for the measured upper binder course, in accordance with the following equation:

$$PI_{ASL} = PI_{MASL} - (PI_{AverageMBS} - PI_{AverageMBF})$$

Where: PI_{ASL} is the Adjusted Profile Index for the affected sublot of surface course,

PI_{MASL} is the Profile Index for the affected sublot of surface course,

$PI_{AverageMBF}$ is the average Profile Index for all of the upper binder course which was measured at the end of the season in which it was constructed.

$PI_{AverageMBS}$ is the average Profile Index for all of the upper binder course which was measured at the beginning of the same season (i.e. in the Spring) in which the affected overlying sublot of surface course is constructed **[see Note 4)]**.

Note 4): The profile index in the spring must be adjusted by the % change in the profile index established at the correlation site at the beginning of the two applicable seasons. The adjustment factor can be obtained from the applicable Regional Quality Assurance Section.

However, if in the Spring, the average profile index for the measured upper binder course **[after being adjusted in accordance with note 4)]** is not more than 5% greater than the average profile index for the measured upper binder in the fall of the same season in which the binder was constructed (or the following season, if the binder is left open for a second winter), then the profile indices for the surface course in all of the affected sublots will remain the same for payment purposes.

It should be noted that the surface course will not be adjusted in any area where the severity of ravelling in the binder course is found to be any worse than very slight in accordance with SP-024, entitled "Manual for Condition Rating of Flexible Pavements – Distress Manifestations".

It should also be noted that, although the profile indices for the surface course will be corrected for carry-over contracts, there will be no such corrections for scallops with "S"-values greater than 10 mm.

Copies of the summary sheets for the measurements taken in the Fall and Spring on the binder courses should be provided to the Bituminous Section.

6-5.5 Damage to Surface Course

If an area of the existing pavement surface after milling and/or padding which underlies a sublot or an area of surface course within a sublot has been damaged, due to circumstances beyond the Contractor's control prior to being measured for payment purposes, then the Contractor must inform the Contract Administrator, in writing, within one business day of the damage occurring.

If such damage has occurred to the existing surface after milling and/or padding, then the Contractor must not cover the affected area until a decision has been made by the Contract Administrator.

The Contract Administrator will evaluate the Contractor's submission and decide if such damage could not have been foreseen by the Contractor, prior to construction. The Contract Administrator will then decide if such an area should be excluded in the final calculation for the payment factor and that decision will be binding on both the Ministry and the Contractor.

6-5.6 QA Testing

The Owner is required to conduct QA testing on a minimum of 10% of the QC (i.e. Contractor) measurements of the surface course which the Contractor will be constructing in a given construction season.

The Contract Administrator is required to choose the number and the locations of a series of randomly-chosen independent QA sections of pavement, from 300 to 1000 m long, which will be measured for QA purposes. Each independent QA section must comprise only complete QC sublots (i.e. the stations at the beginning and end of the sublots should be in multiples of 100 m as in the QC sublots).

Before choosing where these sections are to be located, the Contract Administrator must be given the sketch of sublots (see Section 6-5.1) and also be familiar with the Contractor's plan for the construction of the surface course, especially if it will be done in several phases.

The Contract Administrator must first decide on the number and length of the randomly-chosen independent QA sections which he intends to have measured, assuming that only 10% will be measured. The guidelines shown in Table 6-1 may be used for this purpose.

Table 6-1

# of QC Sublots of Surface Course Constructed Within a Construction Season	Length of Independent QA Sections (m)	# of Independent QA Sections
< 100	300 to 500	2 to 3
100 to <200	300 to 500	3 to 5
200 to < 300	500 to 750	3 to 5
300 to < 500	500 to 750	5 to 7
500 to < 1000	750 to 1000	5 to 13
≥ 1000	1000	≥ 10

Once the length and number of sections has been decided, the Contract Administrator will choose a list of random numbers from Appendix A. Those numbers, which are then ranked from the lowest to the highest, are multiplied by the total number of QC sublots, determined from the Contractor's sketch (note that every sublot on the Contractor's sketch MUST have a unique number). The results are rounded to the nearest whole number using LS-100 (given in Appendix B) to identify the QC sublots which are closest to the midpoint of each independent QA section.

The following example is given below:

Example 1 Contract: 2005-####
# of QC Sublots Constructed in a Season: 254

Step 1: Calculate 10% of # of QC Sublots: 25.4
Step 2: From Table 6-1, choose: 5 QC sections @ 500m each
Step 3: Select 5 random numbers from Appendix A and calculate the sublot closest to the midpoint of the section as follows:

Random#	Ranked Random #	QC Sublot Closest to Midpoint of Randomly-Chosen Section
0.318	0.202	0.202 x 254 = 51.31 (51)
0.801	0.318	0.318 x 254 = 80.77 (81)
0.435	0.435	0.435 x 254 = 110.49 (110)
0.202	0.745	0.745 x 254 = 189.23 (189)
0.745	0.801	0.801 x 254 = 203.45 (203)

Each randomly-chosen QA section must include one of the QC sublots which has been determined by random numbers. That sublot should be as close to the midpoint of the section as possible.

A number of scenarios may occur. For instance, if the calculation causes more than one sublot to fall within the same section, then, another random number (and QA section) should be chosen. Also if the calculation causes two adjacent sections to overlap, then the two sections may be combined and the length of the combined section extended by the length that the two sections overlap. Alternatively, another random number may be chosen for a completely new section, at the discretion of the Contract Administrator.

It has been agreed that all QA sections must be measured within 15 business days of their construction. Therefore, if a QC sublot falls within a section where all of the sublots within that section are not likely to be constructed within, say, two business days of one another, then it would be prudent to shorten that section (to include the most sublots which are likely to be constructed within two days of another) and then an additional random number (and QA section) chosen to represent the excluded sublots. In any case, the pavement sections should be chosen in such a way that the Contractor Administrator can be reasonably assured that the 15 business day requirement for the QA measurements can be easily met.

After a QA section has been constructed, the Contractor should be informed of its location at least 48 hours prior to taking the QA measurements for that section.

The Contract Administrator will designate a third party, to operate an approved, i.e. correlated, PMD, on behalf of the Owner, which will be deemed to be the "Owner's PMD" for such testing.

The disposition of all QA sections resulting from a comparison between the average QA and QC profile index measurements are summarized in Table A of the SP.

Depending upon the outcome of the first couple of independent QA sections, the Contract Administrator might decide to increase the number of measurements beyond the initial 10%.

Although, the intent is to choose a minimum of 10% of the independent QA sections as randomly as possible, specific circumstances may result in more sections being selected using other criteria. For instance, if the Contract Administrator is driving over a section of pavement and the ride does not appear to reflect the numbers that the Contractor is presenting in the profile traces or summary sheets, then the Contract Administrator can have the Owner's PMD measure any other independent QA section as well. Another example may be when a significant difference exists between the QC and QA measure ments for a particular section and the Contract Adminstrator decides to measure adjacent section(s) using the Owner's PMD to determine the extent of the problem.

As part of the QA/QC comparison of the QA sections, the Contract Administrator will also be verifying that the QC summaries and profile traces have correctly identified the number and amplitude of all scallops which have been identified by the QA measurements.

In any single sublot, if the Contract Administrator finds at least one scallop(s) present in the QA trace with an amplitude greater than 11.0 mm that is not identified in the applicable QC trace or the amplitude of at least one of the scallops within that sublot is at least 1.5 mm larger than the amplitude of the same scallop identified on the applicable QC trace and that difference affects how that scallop will be treated (i.e. the QA measurements indicate that the size of its payment reduction increases or that it now must be repaired) then:

a) The QA profile traces and/or summary sheets for the affected sublot will be given to the Contractor,

b) The QA measurements for that sublot will be used for the disposition of any scallops measured by the Owner's PMD within the affected sublot,

c) The QA profile index will be used for the acceptance of the affected sublot, and will take precedence over any adjustment of that sublot based on the QC/QA outcome outlined in Table A of the SP, and

d) The Contractor, may request referee testing (see Section 6-5.7).

For any of the QC/QA comparisons described in this Chapter, the Contractor will be providing all required traffic control, protection and lane closures for up to three separate visits to the site by the Owner's PMD for a combined total of up to 20 hours of measurements (excluding any waiting time in which the Owner's PMD was delayed by the Contractor). For additional QA measurements beyond 20 hours, a change order for additional traffic control, protection and lane closures should be issued.

6-5.7 RefereeTesting

The Contractor may request "Referee Testing" for any individual QA section (based on average profile index measurements) or for an individual sublot (for scallops only).

If the Contractor's written request is received within the specified time frame, then the Contract Administrator will select a company to conduct Referee testing from a list of consultants. The conditions surrounding the Referee testing, how the results are evaluated and the consequences of differences between QA and QC are given in **clauses 313.08.01.05.02 and 313.08.01.05.03 of the** SP.

6-6 Repairs and Redecisioning

Before any repairs are carried out, the contractor will be required to submit a proposal which must be agreed to by the Contract Administrator. The repair options that are available, the extent of repairs as well as the conditions surrounding redecisioning are given in **clauses 313.08.01.05.05.01 and 313.08.01.05.05.02 of the** SP.

If the Contractor has proposed diamond grinding as one of the repair options but the Contractor wishes to grind down more than 5 mm below the general profile of the surrounding pavement surface, then **he** may be required to prove by coring that the design thickness of the surface course will not be reduced by more than 5 mm after the repair. In addition, the slurry that is created by the diamond grinder must be completely removed from the site (i.e. it cannot be simply pumped onto the shoulder or over the shoulder into a drainage ditch) and must disposed of in accordance with all applicable environmental regulations.

It should be noted that some Contractors may propose to use steel drum rollers after the pavement has cooled to improve smoothness. Cold rolling or any other compaction method which has the potential to cause checking will never be considered an acceptable method of repair and should not be accepted by the Contract Administrator.

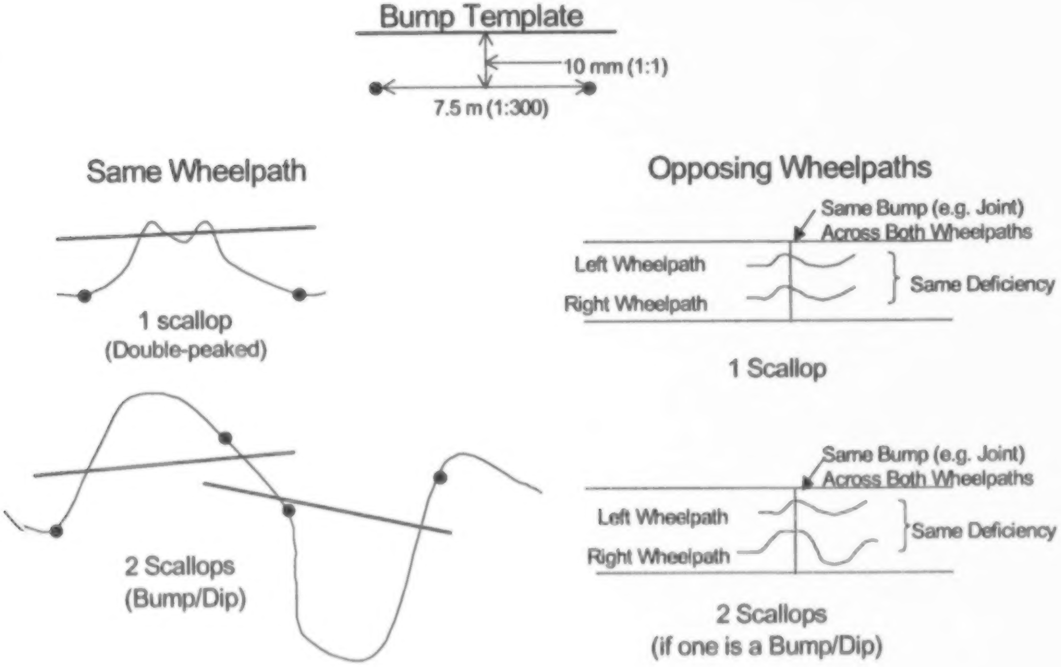
6-7 Payment Issues

Price adjustments, based on profile indices and scallops, are calculated in accordance with the requirements stated in **clause 313.10.01.03** of the SP.

Since scallops can sometimes represent fairly major penalties, Figure 6.5 was compiled to present a few different scenarios in which bumps/dips may be counted either as single scallops or as two separate scallops for payment adjustment purposes. For instance, where two scallops have been recorded in adjacent wheelpaths in the same lane at stations which are within 3 m of one another and they are both left unrepaired, then the two scallops will be treated as a single scallop when being assessed a penalty. In addition, where the profile trace crosses the same "excessive height" line [see Note **5**)], where it is printed on the profile traces, more than once within the same baseline distance of 7.5 m and these bumps are recorded as separate scallops, then these "multiple-peaked" scallops will be treated as a single scallop for penalty assessment purposes.

Note: **5)** It should be noted that McCracken California profilographs actually print out the "excessive height" lines on the traces but Cox profilographs do not, making it much more difficult to define some of these different scenarios. However, this can always be done on any trace by using a bump template to define the maximum amplitude and then by manually drawing the "excessive height" line.

Figure 6-5 : Comparison of One Scallop Versus Two


Bump Template
10 mm (1:1)
7.5 m (1:300)
Same Wheelpath
1 scallop
(Double-peaked)
2 Scallops
(Bump/Dip)
Opposing Wheelpaths
Same Bump (e.g. Joint)
Across Both Wheelpaths
Left Wheelpath
Right Wheelpath
Same Deficiency
1 Scallop
Same Bump (e.g. Joint)
Across Both Wheelpaths
Left Wheelpath
Right Wheelpath
Same Deficiency
2 Scallops
(if one is a Bump/Dip)

6-8 Responsibilities of the Contract Administrator

6-8.1 At the Beginning of the Contract

Since smoothness is included as part of the Inspection Task Manual, the Contract Administrator has several responsibilities related to the administration of the smoothness specification.

1) Review Contractor's Sketch:

At the beginning of the Contract, the Contract Administrator is responsible for reviewing the Contractor's sketch of the sublots in detail. The Contract Administrator must check that the sketch shows all relevent stations, sublot sizes, reference lines and offsets, major intersections, all areas to be measured and areas which are to be measured. It is also important that no two sublots have the same number. Too often the Contractor is using the same sublot number in different lanes which can become extremely confusing when the stations or the lane which is involved are either not included or they turn out to be wrong. Details regarding changes in sublot size near the end-of-lane or adjacent to areas exempt from surface smoothness measurements are given in Section 6-5.1.

It is important to determine if the Contractor has legitimately claimed areas which are to be exempt from measurements. Prior to paving, the Contractor may also ask that other areas be exempt from smoothness measurements. After discussing with the appropriate Region (and the Bituminous Section, if necessary), the sketch may be further modified, if necessary. However, such areas will not be subject to a bonus.

2) Hire a Second Profilograph to Do QA Testing:

The Contract Adminstrator must hire a second profilograph to do QA testing. Such testing must be carried out within 15 business days of the construction of each independent QA section of pavement. The amount tested must be at least 10% of the Contractor's QC sublots.

The consequences of differences between QC and QA results are given in the SP.

Under no circumstances should the QA (or audit) PMD be allowed to follow behind the Contractor's PMD, even if it means the Region has to hire separate traffic protection to accompany the audit PMD at another location (or at a later date).

There may be some cases, however, where representatives of the applicable Regional Quality Assurance Office decide that it may just be too costly or inconvenient to do the QA testing or auditing at some other location (such as projects constructed on limited access highways). If this is the case, then, in addition to the audit measurements, it is recommended that significantly more inspection (≥50%) be provided by a person fully familiar with the operation of a profilograph and the specification at the time the Contractor's PMD is taking the measurements.

The Contractor is required to provide traffic protection, lane closures etc. for up to 3 separate visits representing a combined total of no more than 20 hours of measurements by the Owner's PMD.

Once the QA testing has been done, the applicable Regional Quality Assurance Section should be contacted, prior to discussion with the Contractor.

6-8.2 Prior to Taking Surface Smoothness Measurements Each Day

1) The Contract Administrator must check that at least one person on site from the company that owns the PMD has been approved by the Ministry. The Operator of the PMD, the Contractor's Quality Control Technician (QCT) or the Contractor's Pavement Control Technician (PCT) or their equivalents must have a valid approval card issued by the Ministry which is initialled by Masud Ahmed **or** John Blair [of the Bituminous Section] and Chris Wojcik [or Hannah Schell of the Concrete Section] and signed by the candidate. If there is any question on the validity of the card, the Contract Administrator should contact the applicable Regional Quality Assurance Section (or the Bituminous Section). A list of approved operators will reside with them.

2) The Contract Administrator must note down the make and serial number of the PMD and the engraved letter, serial # and signature on the measuring wheel for the PMD that the Contractor (or Operator) is using, then check with the applicable Regional Quality Assurance Section (or the Bituminous Section) whether that particular PMD and measuring wheel as well as its mode of operation (manual or powered) has been approved for use on Ministry contracts. Of course if the same PMD is being used each day, then there is only a need to check it once.

3) The Contract Administrator must ask and then observe while the Operator checks that the tire pressure of the "bicycle" wheel used for measuring (i.e. the "measuring wheel") is within the allowable limits (i.e 25 +/- 2 p.s.i.).

4) The Contract Administrator must also observe the Operator during the height calibration and occasionally during the distance calibration as well (see Section 6-4.1 and LS 293).

5) Before the PMD Operator begins taking measurements each day, the Contract Administrator must discuss all of the areas to be measured and the reference lines and offsets that the Operator is planning to use that day. If the Contract Administrator does not feel that the reference line is sufficient or that it is not likely to remain in place until the job is completed, then the Contract Administrator can even require that the Contractor mark out the reference line using surveyed nails or some other more permanent method. This also applies to binder courses that are to be measured during the following spring (i.e. carry-overs), since those measurements can significantly affect the payment factor for the overlying surface course

6) The Contract Administrator and either the Operator, QCT or PCT (i.e whoever on site has a valid approval card issued by the Ministry) must sign and date (along with the time) the beginning of the profile record.

6-8.3 Each Hour During Surface Smoothness Measurements

The Contract Administrator should make sure that:

1) The PMD is only taking measurements in the direction of traffic.

2) Any particular sublot and wheelpath is only being measured once (i.e. initial measurements). It should be noted that additional, (i.e. subsequent), measurements may only be taken after repairs or at the request of the Contract Administrator.

   It should be noted that some Contractors have expressed concern that they are not able to carry out their own QC testing on the surface course because the first measurements taken must always be reported to the Contract Administrator for acceptance. The Ministry takes the position that if the Contractor requires QC testing, then such testing should be done on the binder course.

3) Both sets of bogey wheels supporting the device, follow the same path exactly. If these wheels do not follow the same path, then the device is out of alignment and it "crabs" along the wheelpath. The Operator can adjust this fairly easily by loosening a special bolt at the back bogey wheels. It should be stressed that it is the responsibility of the Operator to ensure that the device is always tracking properly. Therefore any measurements taken while the machine is out of alignment are suspect and must be repeated.

When the Operator has finished a run, the Contract Administrator should:

4) Ask and then observe while the Operator checks that the tire pressure of the "measuring wheel" is within allowable limits (i.e 25 +/- 2 p.s.i.) and that the device has been properly calibrated for height (using the calibration blocks).

5) Occasionally sign the profile trace with the date and time. This will allow the Contract Administrator to recall where the Operator was when he made the visit, if there are questions later regarding any suspected inconsistencies.

6-8.4 At the End of Each Day (Before Operator Leaves)

The Contract Administrator should make sure that:

1) The same single, continuous, profile record which the Contract Administrator has signed at the beginning of the day has been received before the PMD Operator leaves the site. Contractually, it is the Contractor's responsibility to ensure that the profile record is given to the Contract Administrator, but the Contract Administrator must do all that is reasonable to make sure that he/she is on site to receive it.

2) The profile record should have enough information on both the outside and inside of the roll so that the results for each wheelpath in every sublot for the surface course and any other surfaces measured can be easily found. The Contract Administrator should not accept any traces without all of the required information.

6-8.5 At the End of Each Day (Back at the Trailer)

The Contract Administrator should:

1) Check again that the daily profile record has enough information so that the rate of smoothness measurements and scallops in every wheelpath and sublot can be easily found.

2) Keep a running summary of the rate of smoothness measurements in both wheelpaths and the heights and locations of all scallops. This is suggested in order to save the Contract Administrator a lot of grief later. If this is not done, the Contract Administrator will be looking through several different daily profile records when he/she has to confirm the results on the summary sheets (which will probably be given to the Contract Administrator at the end of paving). In addition, if the Contract Administrator has a running summary, it makes it much easier to determine if the profile indices being produced by the Contractor appear to be correct. For instance, when the Contract Administrator drives over a section of pavement, he/she can use the running summary to gauge whether the ride he/she experiences reflects the numbers that the Contractor is presenting before the final summary sheets have been given to the Contract Administrator.

6-8.6 After Measurements Are Taken

The Contract Administrator must:

1) Make sure that all relevant summary sheets and profile traces have been received and that all of the required information has been included (see Section 6-5.2) and LS 293.

2) Check that the profile indices from the traces for each wheelpath match those given in the summary sheets.

3) Make sure that all scallops shown on the profile traces have been recorded on the summary sheets and that the Contractor has recorded their amplitudes.

   It should be noted that the amplitudes required are not the numbers given on the traces above the bumps, but must be measured using a bump template and millimetre scale.

4) Determine the overall payment adjustment for the surface course using the average BRD from the cores taken of the applicable mix and the design widths and depths from all measured sublots.

5) If the QA measurements taken by the Owner's PMD (see SP) indicate that, for an independent pavement section, $QA_{avgPI} > 1.10 \times QC_{avgPI}$, then the QA measurements must be given to the Contractor within 20 business days of the construction of the affected sublots.

6) Where the contract is a carry-over and the Contractor elects to measure the upper binder course both in the fall and in the following spring, review the Contractor's profile traces, summary sheets and calculations related to the adjustments of the surface course, based on changes in the upper binder course over the winter **with adjustment for the differences that the applicable PMD recorded at the correlation site [see Note 4)].**

Chapter Seven

ACCEPTANCE OF BRIDGE DECK WATERPROOFING

IT SHOULD BE NOTED THAT EACH LOT MUST BE DECISIONED FOR WATERPROOFING MEMBRANE THICKNESS BEFORE THE BRIDGE IS PAVED. THE CONTRACTOR MUST SIGN FORM PH-CC-129A PRIOR TO PAVING.

7-1 General

The acceptance/rejection criteria for bridge deck waterproofing are covered by OPSS 914 and by special provision.

This section of the Guide has been prepared to assist field staff with the implementation of a statistically-based acceptance procedure for waterproofing membrane which includes a thickness component and a membrane-quality component.

The thickness acceptance/rejection criteria are based on membrane thickness measurements taken in the field, while the quality criteria are based on test results obtained in the Downsview laboratory. The two components or criteria are combined to determine the acceptability of the waterproofing membrane.

Rounding-off should be carried out according to LS-100 given in Appendix B.

When a deck surface not constructed as part of the Contract is to be waterproofed, this acceptance system may be inequitable, if the deck surface is uneven or rough. The Bridge Management Section, Head Office, has prepared guidelines for restoring existing decks to an acceptable surface for waterproofing and acceptance, under this system. Upon mutual agreement of the Regional Area Contracts Engineer, Head Structural Section and Head Quality Assurance, this acceptance procedure may be waived if the deck is considered too rough or uneven. The Engineering Materials Office, Concrete Section, should then be consulted to develop an alternative acceptance method. The Contractor must be advised in writing of changes to the acceptance criteria.

The only change this year is that samples of waterproofing material must be placed in either standard metal concrete cylinder moulds (i.e. they can't be made of plastic) or 4 L "Paint Cans".

NOTES:

1) Process control is the Contractor's responsibility. Do not take thickness measurements of the membrane, as work progresses.

2) Measure membrane thickness for acceptance/rejection after the complete construction of a lot (which includes the placement of protection boards, where appropriate). A lot for bridge deck waterproofing is a deck or part of a deck with an area of 800 m^2 or less (see special provision and OPSS 914, March 1998).

3) The test locations shall be calculated prior to the completion of the lot so that they may be laid out & measurements taken immediately after construction is completed. A second set of locations should also be calculated in case a re-test is required.

4) Acceptance/rejection of the membrane thickness will be based on the mean thickness and standard deviation within a lot.

5) Acceptance/rejection of the membrane quality will be based on a set of adjustment points for each failed test.

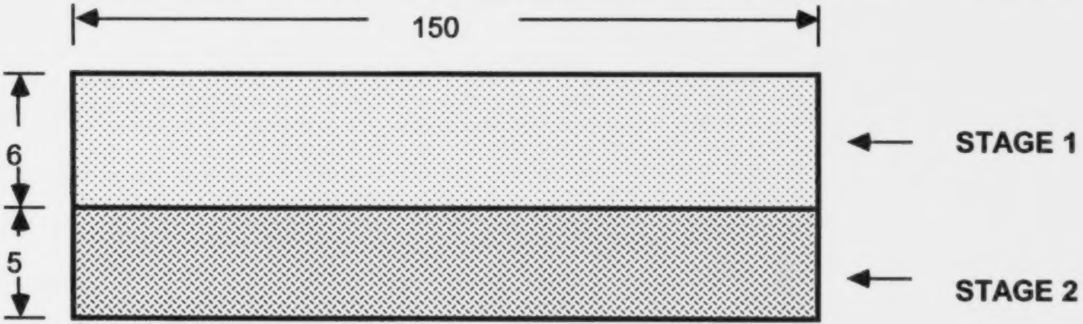
7-2 Sampling and Testing of Membrane Thickness

Membrane Thickness Acceptance Procedure will be discussed by working through the following example:

Step:
1. Compute the area of the deck (by stages)
2. Determine lot size(s) to the closest 0.1 m^2 and assign lot numbers.
   Number lots consecutively per structure through all stages of construction. No structure (site) number should have any duplicate lot numbers.
3. Select random numbers
4. Determine test locations to the closest 0.1 m
5. Measure and record the membrane thickness at each test location
6. Computations
7. Acceptance determination
8. Re-testing
9. Basis of payment

Example

A bridge deck 150 metres long by 11 metres wide is to be waterproofed in two stages in order to maintain traffic on one side. The Contractor wishes to waterproof 6 metres wide on the first side.



Step 1 Compute area of deck (by stages)

Stage 1: 6 x 150 = 900 m^2

Stage 2: 5 x 150 = 750 m^2

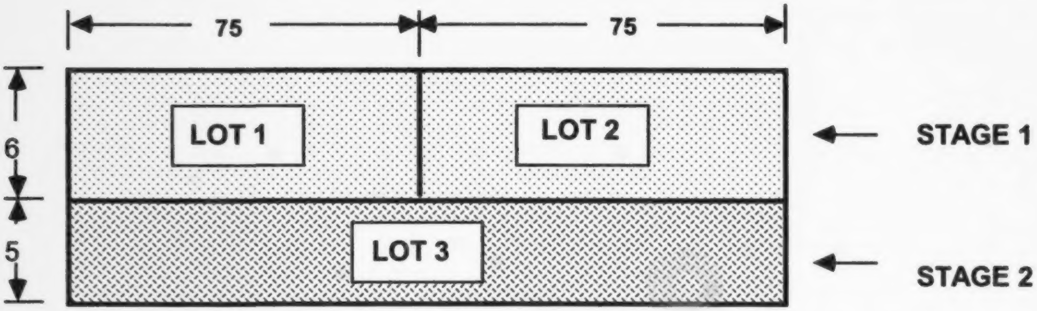
Total = 1650 m^2

Step 2 Determine lot sizes to the closest 0.1 m^2 and assign lot numbers

Since the first stage will have in excess of 800 m^2, it must be divided into two equal lots, each 75 metres long.

The second stage, which has an area under 800 m^2 (i.e. criteria 2), is considered to be a single lot which is numbered lot 3, not lot 1 stage 2.

Note: 6) If the deck is of irregular shape, the lot sizes should be roughly equal in area.



Step 3 Select random numbers

The test locations are obtained by using random numbers.

From a Random Number Table select two sets of ten random numbers from a vertical column or horizontal row. See Sample Random Number Table.

.958	.863	.912	.012	.219	.201	.384	.291	.661	.633
.142	.784	.288	.910	.049	.644	.327	.345	.535	.310
.433	.412	.427	.996	.174	.318	.931	.006	.345	.263
.717	.976	.232	.083	.936	.094	.092	.391	.953	.688
.919	.370	.939	.575	.765	.539	.619	.308	.705	.829
.324	.637	.533	.659	.026	.617	.348	.218	.935	.463
.015	.004	.485	.594	.102	.942	.726	.295	.328	.489
.870	.204	.854	.547	.527	.552	.958	.454	.024	.689
.433	.152	.722	.656	.224	.358	.385	.667	.156	.647
.082	.502	.347	.393	.303	.295	.637	.307	.507	.689
.119	.057	.188	.474	.713	.138	.689	.004	.255	.903
.297	.713	.871	.658	.215	.353	.876	.045	.765	.864

Sample Random Number Table

The numbers in the rows/columns will be used to determine the distance from the end of the lot and the offset location from one edge of the lot.

Note: 7) Avoid using the same rows/columns when calculating a second set of test locations.

Step 4 Determine test locations to the closest 0.1 m

To determine the length (Ls) of each sublot, divide the length of the lot by ten. The Distance into each sublot is then determined by multiplying Ls by a random number.

The Offset from one side of the lot is determined by multiplying a random number by the width of the lot.

Example: Sample Locations for Lot No. 1

Ls = **75** ÷ 10 = **7.5** m; Length of each sublot is therefore **7.5** m.

Sample No.	Start Sublot	+	(Ls x Random No.)	=	Dist. (m)	Width	x	Random No.	=	Offset (m)
1	0.0	+	(7.5 x .919)	=	6.9	6	x	.661	=	4.0
2	7.5	+	(7.5 x .370)	=	10.3	6	x	.535	=	3.2
3	15.0	+	(7.5 x .939)	=	22.0	6	x	.345	=	2.1
4	22.5	+	(7.5 x .575)	=	26.8	6	x	.953	=	5.7
5	30.0	+	(7.5 x .765)	=	35.7	6	x	.705	=	4.2
6	37.5	+	(7.5 x .539)	=	41.5	6	x	.935	=	5.6
7	45.0	+	(7.5 x .619)	=	49.6	6	x	.328	=	2.0
8	52.5	+	(7.5 x .308)	=	54.8	6	x	.024	=	0.1
9	60.0	+	(7.5 x .705)	=	62.3	6	x	.156	=	0.9
10	67.5	+	(7.5 x .829)	=	73.7	6	x	.507	=	3.0

The computed distances and offsets are then copied into the appropriate columns on Form PH-CC-129A.

Step 5 Measure and record membrane thickness at each test location

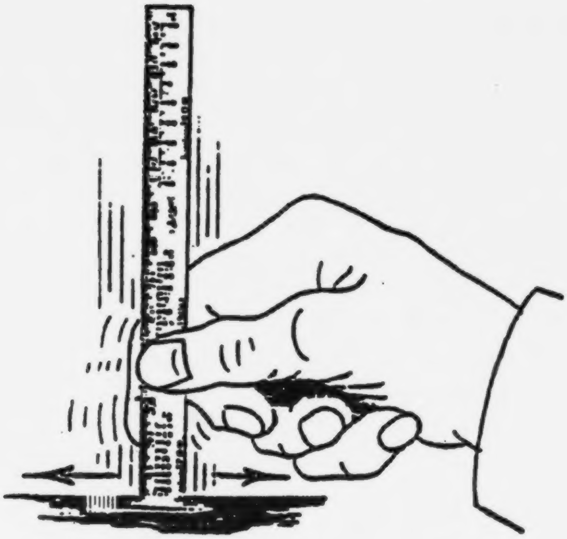
Mark out each computed test location on the deck as soon as construction of the lot is completed.

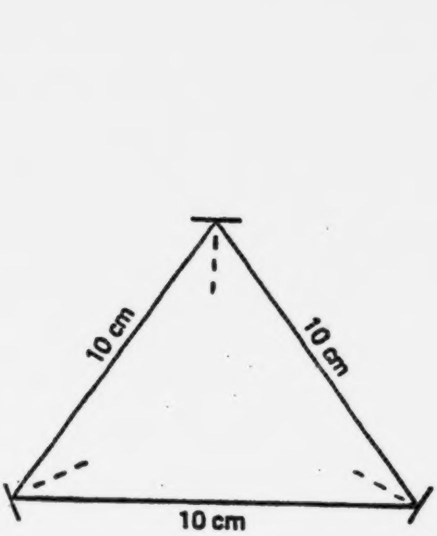
With the asphalt membrane system employing protection boards, you must select the closest upper corner of a protection board to your sample location. Lift up the corner of the board to expose a triangle of membrane approximately 15 cm per side.

With mastic membrane, measure the thickness at the computed distance and offset.

If a test location coincides with the placement of membrane reinforcement, a new random location must be determined for that sublot, to avoid the reinforced area.

The measurement is made with a thin steel scale, such as that supplied with a surveyor's chain for temperature correction or a machinist scale obtained at most hardware stores. The zero end of the scale is worked back and forth in a sawing action until it is in contact with the concrete deck. The thickness of the membrane may then be read directly off the scale. Take three readings, at each location, at the points of an imaginary equilateral triangle with approximate sides of 10 cm. These measurements should be made perpendicular to the bisector of the interior angle, as shown in the diagram below. Average the results of the three readings and round to the closest millimetre using the method shown in APPENDIX B. Record the result on Form PH-CC-129A. (See Figure 7-1).





Note: 8) The end of the Scale must be equal to zero.

Step 6 Computations

1. Add the 10 thickness measurements (T) and record in the box ΣT.
2. Square the sum (ΣT) and record in the Sum ^{2} box (Σ T)^2.
3. Divide the sum (ΣT) by 10 and enter the result, accurate to one decimal place in the Mean box.
4. Square each thickness (T) and enter in the thickness ^{2} column T^2.
5. Add the 10 thickness ^{2} (T^2) and enter in the sum of thickness ^{2} box (ΣT^2).
6. Enter the information from the appropriate boxes into the formula for standard deviation and calculate to four decimal places and then round off to the closest 0.05 using the appropriate rounding procedure shown in see Appendix B.
7. From Table 7-1, determine the pay factor from the intersection of the mean in the vertical columns and the standard deviation in the horizontal rows and enter on the appropriate line.

Step 7 Acceptance determination

7.1 Case 1 - Lot mean is less than 4.0 mm

The entire lot is considered unacceptable. In such cases, the Contractor must make whatever repairs he deems necessary to upgrade the lot. Where applicable, the Contractor should be advised that removed protection boards must be discarded and replaced with new boards. After the repairs are made, the entire lot is to be re-measured and evaluated starting at Step 3 of these instructions.

7.2 Case 2 - Lot mean is greater than or equal to 4.0 mm and less than or equal to 6.0 mm

If the lot is within the acceptable range of Table 7-1, the Contractor will be paid the full contract price.

If the lot is within the unacceptable range of Table 7-1, the Contractor shall be required to repair the lot, as outlined in 7.1. Once repaired, the entire lot will be re-measured and re-evaluated starting at Step 3 of these instructions (i.e. using new test locations).

If the lot is within the borderline range of Table 7-1, the Contractor may repair the lot or he may request that the lot be accepted as is, with a reduced payment, as outlined in Step 9.

7.3 Case 3 - Lot mean is greater than 6.0 mm

If the lot mean is greater than 6.0 mm, regardless of the standard deviation, a review of the conditions that the bridge deck will be exposed to (geometrics, traffic volume, % trucks, etc.) will be made and then the lot will be designated as acceptable, or unacceptable. The reasons for designating the deck acceptable or unacceptable will be discussed with the Contractor. In cases when the lot is designated unacceptable, the Contractor shall be required to repair the lot, as outlined in 7.1. Once repaired, the entire lot will be re-measured and re-evaluated for acceptance starting at Step 3 of these instructions.

Note: 9) Prior to a decision on the disposition of the lot, the Regional Quality Assurance Section must be consulted.

Step 8 Re-testing

The Contractor may request re-testing, if any or all of the ten sublot test values are challenged. If this occurs, the original evaluation will be set aside and 10 new thickness measurements shall be taken in the presence of the Contractor. THE NEW TEST VALUES WILL THEN BE USED TO DETERMINE ACCEPTANCE AND THE RESULTS WILL BE BINDING ON BOTH PARTIES.

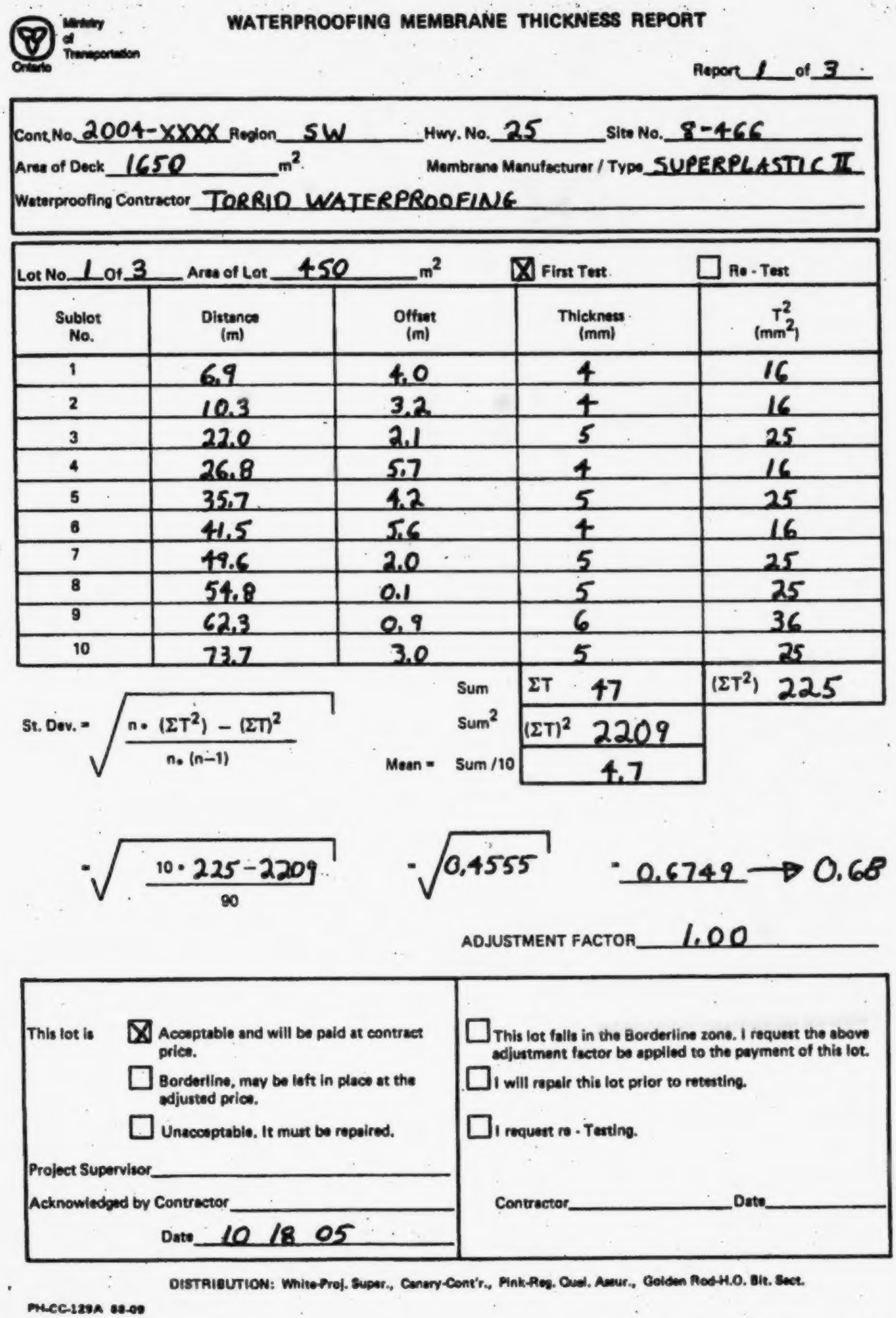
REPAIR OF WORK

Whenever the Authority identifies an unacceptable lot, or whenever the Contractor chooses to improve a borderline lot, the Contractor shall make whatever repairs he deems necessary to upgrade the lot. Any protection boards that are removed shall be replaced with new ones. Once repairs have been completed, the Authority will determine a new set of random locations and will re-measure and re-evaluate the entire lot for acceptance, as described in these instructions.

Step 9 Basis of payment

If the lot is considered acceptable, the Contractor will be paid the contract price for the lot as bid. If the lot is borderline, the lot mean and the lot standard deviation will be applied to Table 1 of the special provision, in order to determine the thickness adjustment factor. Such thickness adjustment factor will then be multiplied by the contract price for the area of the lot, in order to determine payment. In the case of lump sum price, the price of the lot must be prorated before applying the thickness adjustment factor.

FIGURE 7-1 WATERPROOFING MEMBRANE THICKNESS REPORT



Ministry of Transportation Ontario

WATERPROOFING MEMBRANE THICKNESS REPORT

Report 1 of 3

Cont. No. 2004-XXXX Region SW Hwy. No. 25 Site No. 8-466

Area of Deck 1650 m² Membrane Manufacturer / Type SUPERPLASTIC II

Waterproofing Contractor TORRID WATERPROOFING

Lot No. 1 Of 3 Area of Lot 450 m² ☒ First Test ☐ Re - Test

Sublot No.	Distance (m)	Offset (m)	Thickness (mm)	T^2 (mm^2)
1	6.9	4.0	4	16
2	10.3	3.2	4	16
3	22.0	2.1	5	25
4	26.8	5.7	4	16
5	35.7	4.2	5	25
6	41.5	5.6	4	16
7	49.6	2.0	5	25
8	54.8	0.1	5	25
9	62.3	0.9	6	36
10	73.7	3.0	5	25

Sum ΣT 47 (ΣT^2) 225

Sum² $(\Sigma T)^2$ 2209

Mean = Sum /10 4.7

$$\text{St. Dev.} = \sqrt{\frac{n \cdot (\Sigma T^2) - (\Sigma T)^2}{n \cdot (n-1)}}$$

$$= \sqrt{\frac{10 \cdot 225 - 2209}{90}} = \sqrt{0.4555} = 0.6749 \rightarrow 0.68$$

ADJUSTMENT FACTOR 1.00

This lot is ☒ Acceptable and will be paid at contract price.

☐ Borderline, may be left in place at the adjusted price.

☐ Unacceptable. It must be repaired.

Project Supervisor

Acknowledged by Contractor

Date 10 18 05

☐ This lot falls in the Borderline zone. I request the above adjustment factor be applied to the payment of this lot.

☐ I will repair this lot prior to retesting.

☐ I request re - Testing.

Contractor Date

DISTRIBUTION: White-Proj. Super., Canary-Cont'r., Pink-Reg. Qual. Assur., Golden Rod-H.O. Bit. Sect.

PH-CC-129A 88-09

TABLE 7-1 PAYMENT ADJUSTMENT FACTORS FOR BRIDGE DECK WATERPROOFING MEMBRANE THICKNESS

	MEAN																					
STANDARD DEVIATION	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0	STANDARD DEVIATION
0.40																						0.40
0.45	1.00																					0.45
0.50	.99	1.00																				0.50
0.55	.94	.99	1.00																			0.55
0.60	.83	.95	.99	1.00																		0.60
0.65	Una.	.88	.95	.99	1.00																	0.65
0.70		.59	.87	.96	.99	1.00																0.70
0.75		Una.	.71	.89	.96	.99	1.00															0.75
0.80			Una.	.76	.91	.96	.99	1.00														0.80
0.85				Una.	.81	.91	.96	.99	1.00	1.00												0.85
0.90					Una.	.83	.92	.97	.99	.99	1.00											0.90
0.95						.64	.84	.93	.97	.99	.99	1.00										0.95
1.00						Una.	.71	.87	.93	.97	.99	.99	1.00									1.00
1.05							Una.	.76	.87	.94	.97	.99	.99	1.00								1.05
1.10								Una.	.79	.89	.94	.97	.99	.99	1.00							1.10
1.15									.59	.81	.90	.96	.97	.99	.99	1.00						1.15
1.20									Una.	.64	.83	.91	.95	.97	.99	.99	1.00					1.20
1.25										Una.	.71	.84	.91	.95	.97	.99	.99	1.00				1.25
1.30											Una.	.76	.86	.92	.95	.97	.99	.99	1.00			1.30
1.35												Una.	.77	.87	.92	.95	.98	.99	.99	1.00		1.35
1.40													.59	.79	.87	.93	.96	.98	.99	.99	1.00	1.40
1.45													Una.	.68	.82	.88	.93	.96	.98	.99	.99	1.45
1.50														Una.	.71	.83	.89	.93	.96	.98	.99	1.50
1.55															Una.	.74	.84	.90	.94	.96	.98	1.55
1.60																Una.	.78	.86	.91	.94	.96	1.60
1.65																	.64	.79	.87	.91	.94	1.65
1.70																	Una.	.68	.81	.87	.91	1.70
1.75																		Una.	.71	.82	.87	1.75
1.80																			Una.	.74	.83	1.80
1.85																				.59	.76	1.85
1.90																				Una.	.64	1.90
1.95																					Una.	1.95
2.00																						2.00
	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0	
	MEAN																					

All empty cells below cells with pay factors form the unacceptable range

7-3 Sampling and Testing of Membrane Quality

Summary of Membrane Quality Acceptance Procedure

The decision to accept the quality component of the waterproofing membrane will be based on the results of tests performed in accordance with OPSS 1213.

Any lot will be considered acceptable, if all specification requirements are met. Any lot will be considered borderline, if the total number of points resulting from Table 7-2 are less than or equal to 25; or will be considered rejectable, if the total number of adjustment points are greater than 25.

TABLE 7-2 PAYMENT ADJUSTMENT POINTS FOR BRIDGE DECK WATERPROOFING MEMBRANE QUALITY

Test	Specification Limits	Adjustment Points
Cone Penetration at 25 °C	Max 110	0.4 per 1
Cone Penetration at 50 °C	Max 160	0.4 per 1
Flow at 60 °C	Max 3	0.5 per 1
Low temperature flexibility at - 25 °C	Pass	5.0 for Failure
Toughness	Min 5.5	0.5 per 0.1
Toughness/Peak Load	Min 0.040	0.5 per 0.001

Below are the steps to be followed in the field:

Step: 1. Determine when to obtain the sample
2. Obtain the sample
3. Label the sample
4. Ship the sample
5. Compute the quality adjustment factor
6. Compute final payment for the lot

Payment Adjustment for Quality

Example

Step 1 Determine when to obtain the sample

Take the first random number used in determining the distance into the first sublot for the determination of the membrane thickness and calculate when to obtain the sample as follows:

In the previous example, this number was 0.919.

The first digit is used to identify in which sublot the sample will be taken and the second digit is used to identify how far into the sublot it will be taken.

e.g. .919 - 9th Sublot
10% into sublot

.370 - 3rd Sublot
70% into sublot

.024 - 10th Sublot
20% into sublot

Step 2 Obtain the sample

A full 4 L of material is required for laboratory testing. Suitable containers are 4 L "Paint Cans" with double tight lids or standard **metal** concrete cylinder moulds. The "Paint Cans" must be full and the **metal** cylinder moulds must be filled to within 50 mm of the top. "Paint Cans" should be used, if possible, because they can be handled hot; whereas the material has to cool in **the metal** cylinder mould before it can be moved about.

When the Contractor reaches the desired sublot and has waterproofed the approximate percentage of it; provide him with the container and have him draw off the sample and set it out of the way. The Contractor is not to be advised ahead of time, when the sample is to be taken.

Step 3 Label the sample

It is very important that the sample be completely and clearly identified. Use the concrete products field sample sheet (PH-CC-340) and make sure it contains the following information:

1. Contract number,
2. Region,
3. Name of membrane manufacturer,
4. Membrane product name,
5. Date the material was delivered to site,
6. Batch number(s) from manufacturers containers,
7. Temp. of material when sampled from melter,
8. Inspector's name,
9. Date sampled,
10. Field Sample Number,
11. What lot the sample is from and the total number of lots on the deck,
12. Name of waterproofing Contractor,
13. Structure site number.

Place the sample sheet in a brown waterproof envelope (SB-OS-31) and fasten it securely to the sample.

Step 4 Ship the sample

In order to get timely results, it is important to ship the sample quickly to Downsview - certainly within 24 hours of sampling.

Send the sample to:

Concrete Products Laboratory
Ministry of Transportation
1201 Wilson Avenue
Downsview, Ontario
M3M 1J8

Note: 10) If the test results are required very quickly, in order to facilitate the finalising of a Contract, a letter should be enclosed with the sample indicating by what date the results are required. Testing requires a minimum of 5 laboratory working days. Sending samples by courier will expedite urgent work.

Step 5 Compute the quality adjustment factor

Quality Pay Adjustment Factors are calculated as follows:

1. If the sample meets all of the test criteria outlined in Table 2 of special provision, then assign a quality adjustment factor of 1.00.

2. If the sample fails one or more test criteria, then total the adjustment points outlined in Table 2. The quality adjustment factor is then determined by subtracting the total of all of the adjustment points from 100 and then dividing the result by 100.

3. If the adjustment points exceed 25, then the lot is considered rejectable and the Contractor will not be paid for the lot, regardless of the adjustment factor for thickness.

Re-testing for Quality

The Contractor may request re-testing of any sample which results in price adjustment or rejection of a lot, within 30 calendar days of him receiving notification of such. This request must be in writing and a copy of the request must be forwarded to the concrete products laboratory. The results of the re-test shall be used for acceptance and they shall be binding on both parties. If the re-test results in either a price reduction or rejection of the lot, then the Contractor shall be charged for the re-testing at current MTO rates. If the re-test results for the material meet all test criteria (i.e. there is no payment adjustments), then no charge will be levied against the Contractor.

e.g. Sample of Superlastic II from Lot 1

Test		Result	Spec.
Cone Pen.	@ 25 °C	105	Max. 110
	@ 50 °C	184*	Max. 160
Flow	@ 60 °C	4*	Max. 3
Low Temp. Flex.	@ -25 °C	Pass	Pass
Toughness/Peak Load		0.038*	Min. 0.040

In this example, the material failed 3 tests:

1. Cone Pen. @ 50°C by 24 units
2. Flow @ 60°C by 1 unit
3. Toughness/Peak Force by 2 units

The total adjustment per test is determined by multiplying the number of units the test is outside specification by the adjustment points. (From Table 7 - 2).

Cone Pen. @ 50°C	24 x 0.4	=	9.6
Flow @ 60°C	1 x 0.5	=	0.5
Toughness/Peak Force	2 x 0.5	=	1.0
Total:			11.1

The total adjustment points for material quality is equal to the total of the individual test adjustments - in this case 11.1.

The quality adjustment factor is equal to:

$$(100 - 11.1) \div 100 = 88.9 \div 100 = 0.889$$

See the example of a Field Sample Test Report form at the end of this chapter.

Step 6 Compute final payment for the lot

The final payment for the lot will be based on the thickness and on the quality of the waterproofing membrane. The contract price for the lot shall be multiplied by the thickness adjustment factor and the result shall then be multiplied by the quality adjustment factor.

For this example, we will assume that the contract price for the waterproofing is \$28.50/m^2.

Area Lot	=	450.0 m^2		
Contract price	=	450.0 X \$28.50	=	\$12,825.00
Thickness Adjustment Factor	=	1.00		
Adjusted price for thickness	=	\$12,825.00 X 1.00	=	\$12,825.00
Quality Adjustment Factor	=	0.889		
Adjusted price for quality	=	\$12,825.00 X 0.889	=	\$11,401.43
Credit to the Ministry	=	\$12,825.00 -\$11,401.43	=	\$1423.57

FIELD SAMPLE TEST REPORT

File: 3321-2

HOT APPLIED RUBBERIZED ASPHALT WATERPROOFING MEMBRANE

To: Contract Administrator Southwestern Region	From: Materials Engineering & Research Office Concrete Section, Room 235 Building "C", Downsview Complex
Cc: Head, Quality Assurance	Date: February 08, 2006

CONT. NO: 2004-XXXX REGION: SW SITE NO.: 8-466 LOT NO.: 1

MATERIAL NAME: Superlastic II FIELD NO: 1 LAB NO.: 052318

DATE SAMPLED: 10 18 05 DATE RECEIVED: 11 22 05 DATE COMPLETED: 02 03 06

WATERPROOFER Torrid Waterproofing

TEST	SPECIFICATION LIMITS	TEST VALUES	DIFF. OUTSIDE SPEC. LIMIT	ADJUSTMENT POINTS	TOTAL ADJUSTMENT PER TEST
CONE PENETRATION @ 25°C (0.1 mm)	Max. 110	105		0.4 per 1	
CONE PENETRATION @ 50°C (0.1 mm)	Max. 160	184	24	0.4 per 1	9.6
FLOW @ 60°C (mm)	Max. 3	4	1	0.5 per 1	0.5
LOW TEMPERATURE FLEXIBILITY @-25°C	Pass	PASS		5.0 for failure	
TOUGHNESS (Joules)	Min. 5.5	7.1		0.5 per 0.1	
TOUGHNESS/PEAK FORCE (Joules/Newton)	Min. 0.040	0.038	0.002	0.5 per 0.001	1
MASS DENSITY	-	1.21	TOTAL ADJUSTMENT POINTS		11.1

QUALTIY ADJUSTMENT FACTOR = $\frac{100 - \text{TOTAL ADJUSTMENT POINTS}}{100}$ = **0.889**

PROTECTION BOARD THICKNESS (mm)	Min. 3.20 mm Max. 4.00 mm	3.31
MEMBRANE REINFORCEMENT THICKNESS (mm)	-	-

APPENDICES

APPENDIX A:

RANDOM NUMBER TABLE

.318	.801	.435	.202	.745	.489	.900	.027	.827	.279
.922	.683	.847	.320	.476	.421	.893	.826	.444	.619
.726	.473	.854	.662	.381	.761	.661	.868	.174	.799
.711	.341	.219	.228	.466	.683	.676	.327	.502	.469
.978	.631	.469	.885	.267	.510	.601	.135	.290	.025
.689	.152	.703	.533	.742	.335	.670	.521	.007	.590
.521	.351	.824	.854	.347	.792	.542	.590	.051	.713
.960	.690	.343	.019	.917	.876	.365	.271	.942	.355
.991	.530	.165	.042	.448	.626	.526	.926	.607	.827
.713	.765	.812	.496	.626	.770	.331	.770	.662	.200
.141	.266	.141	.919	.199	.520	.332	.526	.752	.991
.966	.697	.704	.305	.831	.842	.740	.050	.925	.239
.681	.637	.035	.023	.335	.799	.623	.673	.509	.480
.106	.702	.879	.408	.519	.929	.416	.584	.486	.818
.635	.427	.554	.288	.318	.983	.844	.858	.059	.851
.507	.673	.434	.163	.060	.375	.025	.514	.848	.637
.297	.057	.951	.411	.441	.564	.171	.693	.052	.063
.817	.663	.369	.038	.653	.001	.321	.506	.886	.920
.763	.580	.967	.071	.368	.351	.950	.098	.529	.793
.496	.290	.698	.183	.504	.687	.005	.814	.954	.356
.314	.490	.174	.925	.886	.170	.496	.453	.835	.546
.306	.360	.103	.152	.234	.654	.941	.108	.980	.439
.444	.097	.321	.233	.725	.434	.416	.919	.578	.493
.178	.245	.433	.486	.622	.175	.238	.108	.637	.215
.984	.396	.434	.416	.101	.104	.597	.875	.543	.576
.574	.639	.116	.101	.754	.982	.358	.444	.856	.269
.648	.264	.090	.088	.176	.867	.485	.794	.388	.790
.764	.412	.018	.018	.523	.060	.329	.655	.313	.135
.899	.070	.117	.270	.914	.048	.048	.584	.566	.209
.792	.356	.793	.143	.640	.582	.267	.216	.824	.437
.489	.886	.430	.327	.315	.988	.426	.805	.934	.717
.238	.089	.246	.485	.958	.600	.253	.142	.082	.320
.635	.122	.911	.217	.136	.907	.322	.090	.216	.392
.557	.997	.727	.181	.510	.704	.349	.505	.863	.872
.244	.180	.057	.721	.359	.643	.432	.780	.052	.125
.546	.478	.347	.550	.471	.608	.325	.426	.002	.398
.593	.238	.636	.852	.030	.196	.939	.804	.453	.222
.660	.685	.385	.749	.813	.926	.004	.225	.115	.425
.339	.388	.357	.853	.634	.170	.448	.564	.383	.310
.755	.918	.791	.359	.414	.149	.799	.173	.156	.482

.511	.455	.333	.085	.021	.048	.265	.797	.430	.371
.941	.656	.523	.385	.994	.813	.012	.823	.502	.839
.673	.721	.637	.123	.748	.661	.372	.018	.243	.837
.623	.125	.748	.141	.648	.765	.933	.514	.969	.321
.498	.162	.692	.878	.474	.159	.751	.130	.691	.831
.731	.909	.171	.055	.139	.911	.113	.100	.178	.526
.556	.031	.853	.660	.417	.154	.051	.984	.881	.607
.652	.347	.261	.626	.778	.667	.321	.987	.404	.102
.815	.058	.984	.893	.741	.420	.400	.853	.715	.406
.567	.607	.476	.847	.120	.358	.313	.226	.091	.065
.651	.121	.116	.531	.112	.952	.329	.659	.328	.426
.380	.119	.809	.074	.450	.294	.254	.992	.543	.468
.117	.790	.119	.214	.858	.563	.163	.630	.185	.112
.689	.342	.174	.450	.134	.503	.421	.835	.607	.458
.871	.947	.688	.521	.923	.904	.436	.405	.400	.370
.976	.402	.486	.070	.999	.912	.375	.307	.134	.183
.530	.153	.153	.665	.521	.673	.595	.136	.507	.350
.433	.142	.067	.485	.816	.919	.963	.090	.751	.109
.247	.575	.220	.881	.124	.531	.012	.304	.165	.532
.985	.274	.841	.514	.476	.054	.371	.445	.131	.143
.153	.225	.585	.818	.598	.942	.333	.875	.250	.343
.091	.363	.923	.765	.005	.723	.899	.040	.114	.329
.491	.031	.258	.483	.518	.486	.840	.473	.544	.420
.231	.641	.742	.545	.179	.239	.142	.285	.170	.939
.931	.282	.138	.982	.406	.460	.059	.632	.239	.478
.587	.524	.683	.925	.145	.942	.385	.789	.371	.284
.580	.031	.961	.573	.009	.041	.992	.477	.556	.334
.334	.334	.106	.583	.892	.252	.111	.046	.604	.406
.967	.493	.221	.596	.314	.105	.328	.298	.385	.056
.367	.069	.941	.022	.162	.689	.959	.192	.896	.887
.980	.035	.631	.863	.234	.175	.946	.286	.678	.269
.673	.050	.559	.199	.416	.973	.543	.284	.157	.683
.356	.760	.248	.205	.054	.122	.160	.689	.197	.248
.578	.991	.208	.348	.259	.215	.946	.718	.795	.626
.589	.082	.788	.836	.125	.718	.733	.158	.493	.834
.358	.241	.973	.766	.790	.027	.703	.111	.136	.417
.369	.227	.963	.801	.718	.581	.254	.753	.451	.029
.379	.696	.880	.955	.858	.861	.443	.131	.858	.861
.327	.443	.131	.858	.619	.604	.277	.663	.156	.058
.567	.356	.247	.001	.124	.458	.646	.894	.576	.893

APPENDIX B:

LS-100

METHOD FOR ROUNDING-OFF OF TEST DATA AND OTHER NUMBERS

1. SCOPE

1.1 This method describes the procedure to be used for the rounding-off of all numbers.

2. GENERAL

Test values and calculated values are to be rounded in accordance with the criteria prescribed in Section 3.0.

3. CRITERIA

3.1 When the digit beyond the last place to be retained is less than 5, then the digit in the last place retained will remain (see Examples 1 & 2).

3.2 When the digit beyond the last place to be retained is greater than or equal to 5, then the digit in the last place to be retained will be increased by 1 (see Examples 1 & 2).

3.3 When a number is to be rounded, it will be rounded in one step only to the precision required and not rounded in two or more consecutive steps. For example: the number 1.347 can be rounded to 1.35 (to two decimal places). However, it is not acceptable to subsequently take 1.35 and then round it to the value of 1.4 to obtain a precision to one decimal place. In the method described herein, 1.347, rounded to one decimal place would have a value of 1.3.

NOTE 1: The requirement of rounding in one step does not refer to a rounded result which may have been obtained from a formula that may itself consist of rounded numbers. For example, it is perfectly acceptable to use % passing results which are themselves rounded to produce a rounded fineness modulus.

3.4 If, in special cases, it is desired to round off a number to the nearest 5, 0.5,0.05, 0.005 etc., then the observed or calculated value (with any number of significant digits) will be doubled, then respectively rounded to the nearest 10, 1, 0.1, 0.01 etc., in accordance with 3.1 to 3.3. The rounded result will then be divided by 2 (see Example 3).

Examples:

Example #1
Rounding to the closest whole number:

4.49 = 4 7.49 = 7
4.50 = 5 7.50 = 8
4.5 = 5 7.5 = 8
4.51 = 5 7.51 = 8

Example #2
Rounding to the closest 0.1:

7.649 =7.6 7.349 =7.3
7.650 =7.7 7.350 =7.4
7.65 =7.7 7.35 =7.4
7.651 =7.7 7.351 =7.4

Example #3
Rounding to the closest 0.05:

1.1249 x 2 = 2.2498 : 2.2 / 2 = 1.10
1.1250 x 2 = 2.2500 : 2.3 / 2 = 1.15
1.125 x 2 = 2.250 : 2.3 / 2 = 1.15
1.126 x 2 = 2.252 : 2.3 / 2 = 1.15

APPENDIX C:

METHOD FOR CALCULATION OF PER CENT WITHIN LIMITS

1. SCOPE

1.1 This method describes the procedure to be used for calculation of Per cent Within Limits.

2. RELEVANT DOCUMENTS

2.1 MTO Test Methods LS-100

3. DEFINITIONS

3.1 Per cent Within Limits (PWL) is an estimate of the percentage of the population (lot) that is within specification limits, determined by using the mean and standard deviation of the lot.

3.2 Mean ($\overline{X}$) is the arithmetic average of a set of test results.

3.3 Lot Standard Deviation (s) is the square root of the value found by summing the squares of the difference between each test result and the mean of the test results divided by the number of test results minus one (n-1).

3.4 Quality Index (Q_i) is a statistic which, when used with appropriate tables, provides an estimate of PWL of a lot. It can be based on an Upper or Lower Specification Limit, yielding Q_U or Q_L respectively.

4. GENERAL

4.1 All test results for a lot will be combined to calculate the Mean and Standard Deviation of the lot which will then be used to determine the Per cent Within Limits (PWL), according to the procedures in Section 5.

4.2 Any necessary rounding-off of test results or calculations will be in accordance with LS-100.

4.3 The lot mean will be reported to one decimal place. The Lot Standard Deviation, Lower Quality Index, and Upper Quality Index will be reported to two decimal places.

5. CALCULATIONS

5.1 The Quality Index, Q_i, for the lower and upper specification limits shall be as determined from the following formulae:

$$Q_L = \frac{\overline{X} - LL}{s} \qquad Q_U = \frac{UL - \overline{X}}{s}$$

where:
Q_L = Lower Quality Index Value
Q_U = Upper Quality Index Value
LL = Lower Specification Limit
UL = Upper Specification Limit
$\overline{X}$ = lot mean
s = lot standard deviation

5.2 PWL shall be determined from the following formula: PWL = $(P_L + P_U) - 100$

where: PWL = Per cent Within Limits
P_L = Per cent Within Lower Limit
P_U = Per cent Within Upper Limit

P_L and P_U are each determined from Table 1 based on Q_L and Q_U and the number of test results (n).

Where a lower limit is not specified, P_L will be 100. Where an upper limit is 100% or is not specified, P_U will be 100.

5.3 Notes for Table 1:

1. Enter the table using the number of test results and Q value.
2. If the value of Q_L or Q_U does not correspond exactly to a value in Table 1, use the next highest value of Q_L or Q_U from the table. The maximum P_L or P_U is 100.
3. Move across the table horizontally from the appropriate Q value to get P_L or P_U.
4. For negative values of Q_L or Q_U, enter the table using the absolute value of Q. P_L or P_U is equal to 100 minus the value from Table 1 for P_L or P_U.

6. EXAMPLES

6.1 Mean ($\overline{X}$) = 35.4 Lower Specification Limit (LL) = 30
Standard Deviation (s) = 3.22 Number of Test Results (n) = 42

$$Q_L = \frac{\overline{X} - LL}{s} = \frac{35.4 - 30}{3.22}$$

$$Q_L = 1.68$$

Look in Table 1 under n = 42 (see column n = 38 to n = 69).

As Q_L = 1.68 does not correspond exactly to a value in the table, use the next highest value in the column, 1.73.

Look across the table to the corresponding value of P_L = 96.

P_U = 100 (no upper limit is specified).

$$\begin{aligned} PWL &= (P_L + P_U) - 100 \\ &= (96 + 100) - 100 \\ &= 96 \end{aligned}$$

6.2 Mean ($\overline{X}$) = 95.3 Lower Specification Limit (LL) = 91.5

Standard Deviation (s)= 2.87 Upper Specification Limit (UL) = 97.0

Number of Test Results (n) = 12

$$Q_L = \frac{\overline{X} - LL}{s} = \frac{95.3 - 91.5}{2.87} \qquad Q_U = \frac{UL - \overline{X}}{s} = \frac{97.0 - 95.3}{2.87}$$

$$Q_L = 1.32 \qquad Q_U = 0.59$$

From Table 1: $P_L = 91$

$P_U = 72$

$$\begin{aligned} PWL &= (P_L + P_U) - 100 \\ &= (91 + 72) - 100 \\ &= 63 \end{aligned}$$

6.3 Mean ($\overline{X}$) = 222.4 Upper Specification Limit (UL) = 220

Standard Deviation (s) = 8.72 Number of Test Results (n) = 61

$$Q_U = \frac{UL - \overline{X}}{s} = \frac{220 - 222.4}{8.72}$$

$$Q_U = -0.28$$

From Table 1, a Q_i of 0.28 gives a P_i of 61, however, as Q_U is negative.

$P_U = 100 - 61 = 39$

P_L = 100 (no lower limit is specified)

$$\begin{aligned} PWL &= (P_L + P_U) - 100 \\ &= (100 + 39) - 100 \\ &= 39 \end{aligned}$$

TABLE 1: Values for P_L and P_U for a Given Quality Index and Number of Tests

P_L or P_U	Quality Index (Q_L or Q_U)														
	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10 to n=11	n=12 to n=14	n=15 to n=18	n=19 to n=25	n=26 to n=37	n=38 to n=69	n=70 to n=200	n>200
100	1.16	1.50	1.79	2.03	2.23	2.39	2.53	2.65	2.83	3.03	3.20	3.38	3.54	3.70	3.83
99	1.16	1.47	1.67	1.80	1.89	1.95	2.00	2.04	2.09	2.14	2.18	2.22	2.26	2.29	2.31
98	1.15	1.44	1.60	1.70	1.76	1.81	1.84	1.86	1.91	1.93	1.96	1.99	2.01	2.03	2.05
97	1.15	1.41	1.54	1.62	1.67	1.70	1.72	1.74	1.77	1.79	1.81	1.83	1.85	1.86	1.87
96	1.14	1.38	1.49	1.55	1.59	1.61	1.63	1.65	1.67	1.68	1.70	1.71	1.73	1.74	1.75
95	1.14	1.35	1.44	1.49	1.52	1.54	1.55	1.56	1.58	1.59	1.61	1.62	1.63	1.63	1.64
94	1.13	1.32	1.39	1.43	1.46	1.47	1.48	1.49	1.50	1.51	1.52	1.53	1.54	1.55	1.55
93	1.13	1.29	1.35	1.38	1.40	1.41	1.42	1.43	1.44	1.44	1.45	1.46	1.46	1.47	1.47
92	1.12	1.26	1.31	1.33	1.35	1.36	1.36	1.37	1.37	1.38	1.39	1.39	1.40	1.40	1.40
91	1.11	1.23	1.27	1.29	1.30	1.30	1.31	1.31	1.32	1.32	1.33	1.33	1.33	1.34	1.34
90	1.10	1.20	1.23	1.24	1.25	1.25	1.26	1.26	1.26	1.27	1.27	1.27	1.28	1.28	1.28
89	1.09	1.17	1.19	1.20	1.20	1.21	1.21	1.21	1.21	1.22	1.22	1.22	1.22	1.22	1.23
88	1.07	1.14	1.15	1.16	1.16	1.16	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17
87	1.06	1.11	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.13
86	1.04	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08
85	1.03	1.05	1.05	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04
84	1.01	1.02	1.01	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99
83	1.00	0.99	0.98	0.97	0.97	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.95	0.95	0.95
82	0.97	0.96	0.95	0.94	0.93	0.93	0.93	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
81	0.96	0.93	0.91	0.90	0.89	0.89	0.89	0.89	0.89	0.88	0.88	0.88	0.88	0.88	0.88
80	0.93	0.90	0.88	0.87	0.86	0.86	0.86	0.85	0.85	0.85	0.85	0.84	0.84	0.84	0.84
79	0.91	0.87	0.85	0.84	0.83	0.82	0.82	0.82	0.82	0.81	0.81	0.81	0.81	0.81	0.81
78	0.89	0.84	0.82	0.80	0.80	0.79	0.79	0.79	0.78	0.78	0.78	0.78	0.77	0.77	0.77
77	0.87	0.81	0.78	0.77	0.76	0.76	0.76	0.75	0.75	0.75	0.75	0.74	0.74	0.74	0.74
76	0.84	0.78	0.75	0.74	0.73	0.73	0.72	0.72	0.72	0.71	0.71	0.71	0.71	0.71	0.71
75	0.82	0.75	0.72	0.71	0.70	0.70	0.69	0.69	0.69	0.68	0.68	0.68	0.68	0.68	0.67
74	0.79	0.72	0.69	0.68	0.67	0.66	0.66	0.66	0.66	0.65	0.65	0.65	0.65	0.64	0.64
73	0.76	0.69	0.66	0.65	0.64	0.63	0.63	0.63	0.62	0.62	0.62	0.62	0.62	0.61	0.61
72	0.74	0.66	0.63	0.62	0.61	0.60	0.60	0.60	0.59	0.59	0.59	0.59	0.59	0.58	0.58
71	0.71	0.63	0.60	0.59	0.58	0.57	0.57	0.57	0.57	0.56	0.56	0.56	0.56	0.55	0.55
70	0.68	0.60	0.57	0.56	0.55	0.55	0.54	0.54	0.54	0.53	0.53	0.53	0.53	0.53	0.52
69	0.65	0.57	0.54	0.53	0.52	0.52	0.51	0.51	0.51	0.50	0.50	0.50	0.50	0.50	0.50
68	0.62	0.54	0.51	0.50	0.49	0.49	0.48	0.48	0.48	0.48	0.47	0.47	0.47	0.47	0.47
67	0.59	0.51	0.47	0.47	0.46	0.46	0.46	0.45	0.45	0.45	0.45	0.44	0.44	0.44	0.44
66	0.56	0.48	0.45	0.44	0.44	0.43	0.43	0.43	0.42	0.42	0.42	0.42	0.41	0.41	0.41
65	0.52	0.45	0.43	0.41	0.41	0.40	0.40	0.40	0.40	0.39	0.39	0.39	0.39	0.39	0.39
64	0.49	0.42	0.40	0.39	0.38	0.38	0.37	0.37	0.37	0.37	0.36	0.36	0.36	0.36	0.36
63	0.46	0.39	0.37	0.36	0.35	0.35	0.35	0.34	0.34	0.34	0.34	0.34	0.33	0.33	0.33
62	0.43	0.36	0.34	0.33	0.32	0.32	0.32	0.32	0.31	0.31	0.31	0.31	0.31	0.31	0.31
61	0.39	0.33	0.31	0.30	0.30	0.29	0.29	0.29	0.29	0.29	0.28	0.28	0.28	0.28	0.28
60	0.36	0.30	0.28	0.27	0.27	0.27	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.25	0.25
59	0.32	0.27	0.25	0.25	0.24	0.24	0.24	0.24	0.23	0.23	0.23	0.23	0.23	0.23	0.23
58	0.29	0.24	0.23	0.22	0.21	0.21	0.21	0.21	0.21	0.21	0.20	0.20	0.20	0.20	0.20
57	0.25	0.21	0.20	0.19	0.19	0.19	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
56	0.22	0.18	0.17	0.16	0.16	0.16	0.16	0.16	0.16	0.15	0.15	0.15	0.15	0.15	0.15
55	0.18	0.15	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
54	0.14	0.12	0.11	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
53	0.11	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
52	0.07	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
51	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02
50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX D:

APPLICATION FOR FIELD ADJUSTMENT TO JMF

FROM: ______________________________ **DATE:** ____________________
CONTRACTOR

TO: _________________________________ **CONTRACT:** ________________
CONTRACT ADMINISTRATOR

Re: Field Adjustment To JMF **For Superpave and SMA Mixes**

In accordance with **Subsection 313.07.13 of OPSS 313**, ____________________________ (Contractor) proposes to change the Job Mix Formula on this Contract for Tender Item No._____, ______________(type of mix). It is requested that the change become effective ___________________(date) starting with Lot ___________ of this item.

This change is being made in conformance with Situation ____ [Insert **a)**, **b)** or **c)** here] identified below:

a) To more closely reflect the actual mix being produced when test results for the last lot produced to the submitted JMF accrued a payment reduction for asphalt cement content and/or aggregate gradation but met all other specified mix requirements. Table 1 confirms that the test results (lot mean) meet the design requirements for VMA, percent G_{mm} at N_{max}., voids filled with asphalt (VFA) and dust proportion and that there was no payment reduction for air voids.

b) To permit minor changes in the constituent proportions when test results for the last lot produced to the submitted JMF indicated no negative price adjustments for asphalt cement or gradation, but changes are designed to improve either the air voids or the VMA or both. Table 2 confirms that the air voids PWL is presently at least 50 and the lot mean VMA is no more than 0.5 percent below the design minimum. Test results summarized in this table confirm improvements in these attributes, without any deterioration in the remainder of mix properties.

c) To permit minor changes in the submitted JMF before production starts. Table 3 confirms that the revised JMF will provide a mix meeting all design criteria.

Revised JMF:
The original and revised JMF, and the changes in the target AC content and gradation, are summarized below:

	JMF from Mix Design	Revised JMF #1	Revised JMF #2	Change from Mix Design JMF	Max. Permitted Change
AC Content–all mixes except SMA					± 0.2 %
AC Content –SMA only					± 0.4 %
Sieve	**% Passing**				
26.5/25.0 mm					± 5.0 %
19.0 mm					± 5.0 %
16.0 mm					± 5.0 %
13.2/12.5 mm					± 4.0 %
9.5 mm					± 4.0 %
4.75 mm					± 3.0 %
2.36 mm					± 3.0 %
1.18 mm					± 3.0 %
600 µm					No limit
300 µm					
150 µm					
75 µm – all mixes except SMA					± 1.0 %
75 µm – SMA only					± 2.0 %

____
CONTRACTOR'S REPRESENTATIVE

Contract Administrator's Response

☐ Your revised JMF outlined above (and the submitted documentation) have been reviewed and confirmed to conform to contract requirements. The revision will be applied to Lot _____ and to subsequent lots. Confirmation of conformance to Contract requirements of the revised JMF does not constitute any guarantee that the mix can be produced and/or constructed to Contract requirements, and does not relieve the Contractor of the responsibility for ensuring the specified quality of materials and workmanship is achieved.

☐ Your revised JMF outlined above (and the submitted documentation) have been reviewed. Permission to use the revised JMF is denied for the following reason(s).

____

____

____

CONTRACT ADMINISTRATOR **Date**

Supporting Documentation

(Contractor to complete Tables 1, 2 or 3 corresponding to Situations a), b) or c) identified previously)

Situation 1: The test results (lot mean) shall show that the design requirements for VMA, percent G_{mm} at N_{max}., voids filled with asphalt (VFA) and dust proportion, **where applicable [see Note 1)]**, were met and that there was no payment reduction for air voids. The following table confirms that these conditions have been satisfied.

Table 1: Confirmatory Information For Situation 1

Properties [See Note 1)]	Original Properties (from Lot _____) [see Note 2)]	Conditions
PF for AC and/or gradation		< 1.000
PF for Air Voids		≥1.000
		Design Requirements
VMA		
Percent G_{mm} at N_{ini}		
Percent G_{mm} at N_{max}		
VFA		
Dust Proportion		

Notes: 1) **For Superpave mixes, all properties apply. However, for SMA, only the PF for AC and/or gradation and VMA apply.**

2) From QC testing or referee testing

Situation 2: To permit minor changes in the constituent proportions when test results for the last lot produced to the submitted JMF indicated no negative price adjustments for asphalt cement or gradation, but changes are designed to improve either the air voids or the VMA or both **for Superpave mixes, or the air voids only for SMA**. For this situation, the constructed lot **shall not be rejectable for** air voids and, **for Superpave mixes only,** the lot mean VMA shall be no more than 0.5 percent below the design minimum. The proposed JMF shall yield a mix which improves on this, and shows no deterioration in the remainder of the mix properties.

Table 2: Mix Properties of Constructed Lot and Proposed JMF

Properties [See Note 3)]	**Based on Constructed Lot ____ (Note 4)**	**Conditions**	**Based on proposed JMF (Note 5)**
PF for AC and grading		≥1.000	N/A
Air Voids		**Lot is not rejectable**	N/A
VMA		≤ 0.5% below design minimum	
		Requirements	
Percent G_{mm} at N_{ini}		N/A	
Percent G_{mm} at N_{max}		N/A	
VFA		N/A	
Dust Proportion		N/A	

Notes:
3) **For Superpave mixes, all properties apply. However, for SMA, only the PF for AC and/or gradation and Air Voids apply.**
4) From QC testing or referee testing
5) Attach results (mean of 4 plant checks or testing of laboratory constituted mix)
6) The properties resulting from this revised JMF must continue to conform to design requirements or show no deterioration thereof.

Situation 3: To permit minor changes in the submitted JMF before production starts.

Table 3: Mix Properties - Mix Design and Proposed JMF

Properties [See Note 7)]	**From Submitted Mix Design**	**From Proposed JMF [Note 8)]**	**Design Requirements**
Air Voids			
VMA			
Percent G_{mm} at N_{ini}			
Percent G_{mm} at N_{max}			
VFA			
Dust Proportion			

Notes:
7) **For Superpave mixes, all properties apply. However, for SMA, only Air Voids and VMA apply.**
8) Attach laboratory test results (mean of 4 plant checks or testing of laboratory constituted mix)

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APPENDIX E:

LIST OF REFEREE LABORATORIES

PARTICIPANT / ADDRESS	Contact Name	***Phone*** (Fax)	E-mail
AMEC Earth & Environmental Ltd. 505 Woodward Avenue, Hamilton, Ontario L8H 6N6	Hoda Seddik	**905-321-0700** 905-730-3924-cell (905-312-0771)-fax	Hoda.Seddik@amec.com
AMEC Earth & Environmental Ltd. 104 Crockford Boulevard, Scarborough, Ontario, M1R 3C3	Sufi Mohammadsarif or George Chow	**416-751-6565, ext. 229** **(George Chow, ext. 232)** (416-751-7592)-fax	Mohammadsarif.Sufi@amec.com Chow.George@amec.com
DBA Engineering Ltd. 370 Steelcase Road East, Markham, Ontario L3R 1G2	Andrew Burleigh	**905-940-8383** (905-940-8508)-fax	aburleigh@dbaeng.com info@dbaeng.com
DST Consulting Engineers Inc. 605 Hewitson Street, Thunder Bay, Ontario P7B 4V4	Bruno Conedese or Scott Tozer	**807-623-2929** (807-623-1792)-fax	ThunderBay@dstgroup.com
Golder Associates Ltd. 100 Scotia Court, Unit 22, Whitby, Ontario L1N 8Y6	John Watkins	**905-723-2727** (905-723-2182)-fax	jwatkins@golder.com
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